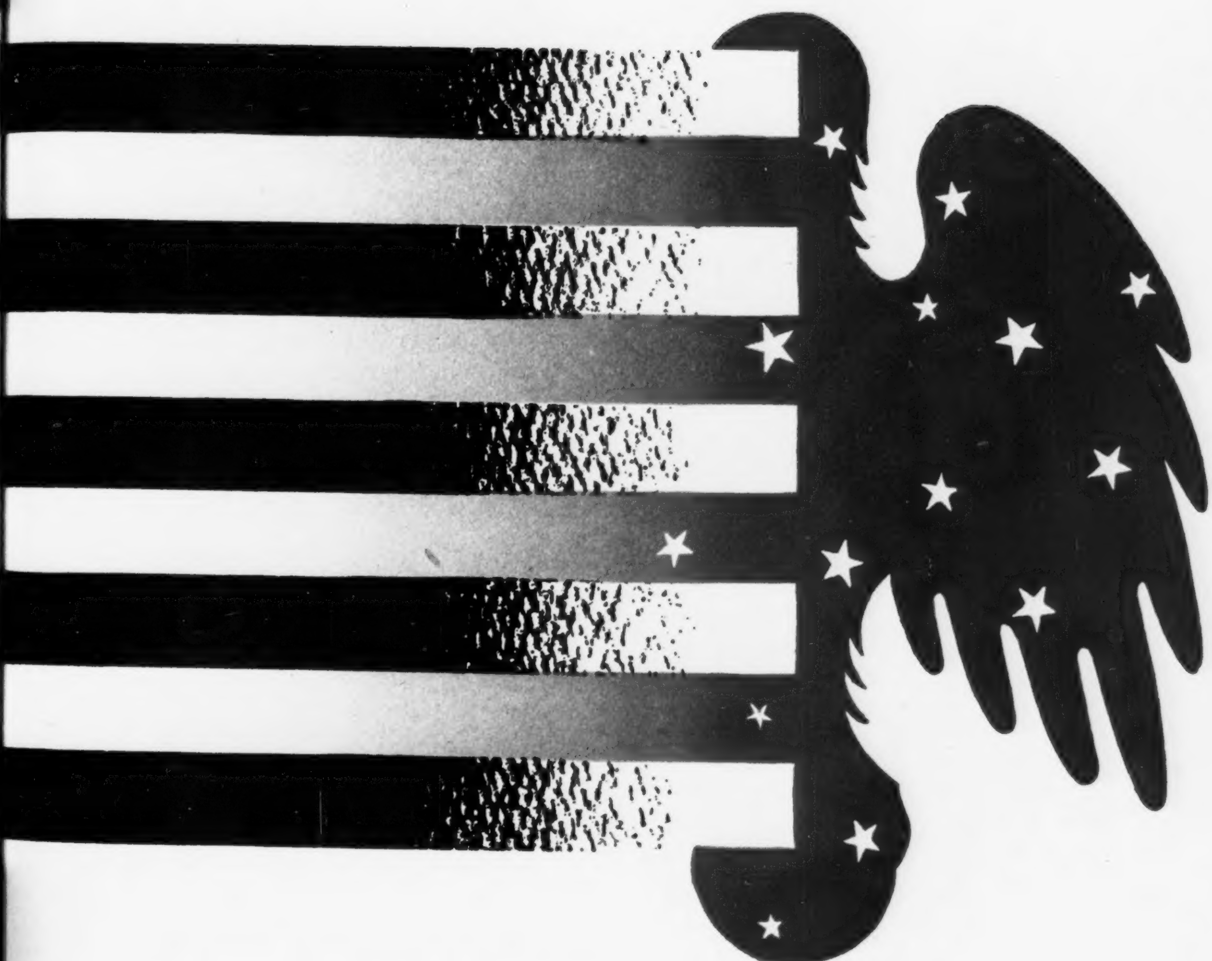
VOL. XXV NO. 7—JULY 1947



BELL LABORATORIES

RECORD

A monthly magazine for members of Bell Telephone Laboratories, for their associates in the Bell System and for others interested in the progress of the communication art.

CONTENTS OF THIS ISSUE

Published monthly by **BELL TELEPHONE LABORATORIES INCORPORATED**
463 WEST STREET, NEW YORK 14, N. Y.

O. E. BUCKLEY, president **J. W. FARRELL,** secretary **W. C. BURGER,** treasurer

PAUL B. FINDLEY, editor **PHILIP C. JONES,** science editor **R. LINSLEY SHEPHERD,** associate editor
HELEN McLOUGHLIN, assistant editor **LEAH E. SMITH,** circulation manager

Printed in U. S. A. **SUBSCRIPTIONS,** $2.00 per year FOREIGN, $2.60 per year

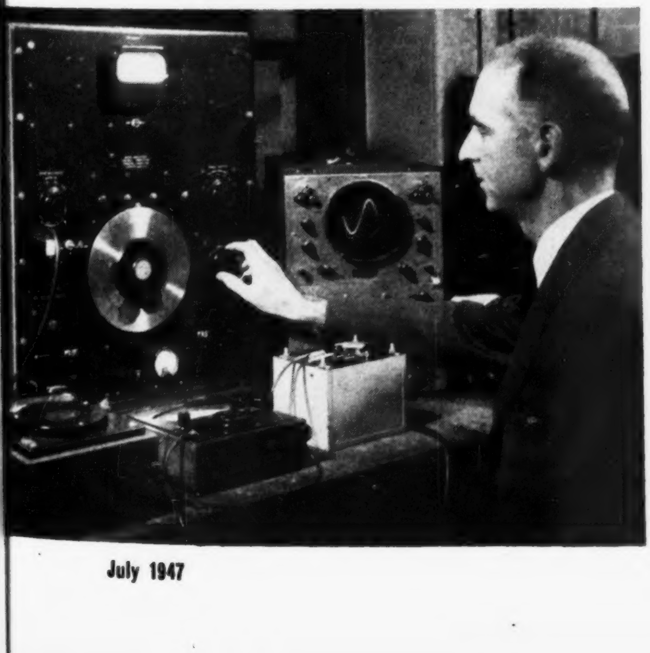
BELL LABORATORIES RECORD

VOL. XXV NO. 7—JULY 1947

M. S. BURGESS
Transmission
Apparatus
Development

A MULTIPLE OUTPUT STATIC FREQUENCY GENERATOR

During the war the Laboratories developed an ultra-high-frequency runway localizer receiver to be used in airplanes as part of a radio instrument landing system. Thousands of these receivers were manufactured by the Western Electric Company for the Army Air Forces. An instrument in the plane, operating on the output of this receiver, indicates how much the plane is to one side or the other of the center of the landing strip. In the ground transmitter a 109.9-mc carrier is modulated with 90 and 150 cycles, and these modulated outputs produce two lateral guidance radiation patterns as shown in Figure 1. The center-line between these two patterns is lined up with the center of the runway, and along this line the 90- and 150-cycle demodulated outputs are of equal magnitude, while at either side one or the other predominates, and gives a corresponding indication on the instrument. Thus for a plane approaching along the line shown dotted in Figure 1, the magnitude of the 150-cycle demodulated output would be proportional to OA, while that for the 90-cycle demodulated output would be proportional to OB.



To test these receivers before shipment from the factory, two similarly modulated signals were required. In the ground transmitter a mechanical modulator driven by a synchronous motor is employed to derive the two frequencies, and thus the radiated signals maintain a fixed ratio between their frequencies regardless of slight variations in absolute value. This characteristic is essential to the correct operation of the receiver, and would thus have to be duplicated in the test set. It was also required that for changes in absolute value of frequency up to 1.5 per cent, the output level should not vary by more than 0.05 db. Incorporating these characteristics, a circuit for testing the receivers was designed by R. D. Gibson, who also participated in the design of the localizer receiver.

This testing circuit and its association with the receiver for test is shown in Figure

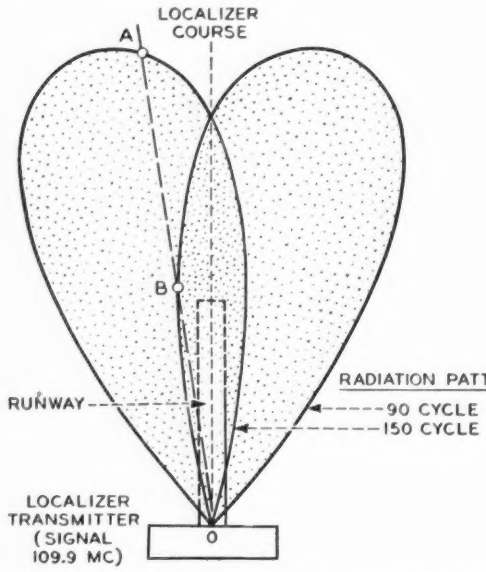


Fig. 1—Radiation pattern of the ground transmitter forming part of the runway localizer system

2. Since the two test frequencies must remain in fixed ratio to each other, it was decided to employ harmonics of a single 30-cycle oscillator, shown at the left. The third and fifth harmonics of this fundamental frequency—90 and 150 cycles, respectively—are produced in the frequency generator. Each of the frequencies derived from the frequency generator is passed through an amplifier with automatic volume control and then through a common amplifier. These amplified signals are connected to a signal generator where they modulate a 109.9-mc carrier to produce signals duplicating those sent out by the ground transmitter.

In the localizer receiver, following the amplifier and demodulator, are 90- and 150-cycle filters and rectifiers that provide direct currents proportional to the 90- and 150-cycle signals. These two currents operate the instrument that indicates to which side and how much the plane is off the center of the runway. A change in level of 0.05 db, which is the limiting requirement, corresponds to a 7-inch departure from the centerline of the runway when the plane is 1,000 feet from the transmitter, while full-scale deflection of the instrument corresponds to 41 feet.

For a factory test, the output of the signal generator of the test set is passed to the receiver. Provisions are made for introducing a 1.5 per cent change in frequency of the 30-cycle oscillator, and for varying the output of the 150-cycle supply by ± 0.05 db so that the receiver may be checked at the extremes of its requirements.

The heart of this test circuit is the frequency generator, Figures 3 and 4. Current from the 30-cycle oscillator is supplied to the primary of the transformer T1 through a condenser C1, which serves to reduce the primary reactance and to maintain a sinusoidal current through the primary winding. There are two secondary windings with separate output circuits, each containing a series condenser—C2 and C4, respectively—and a tuned circuit consisting of a

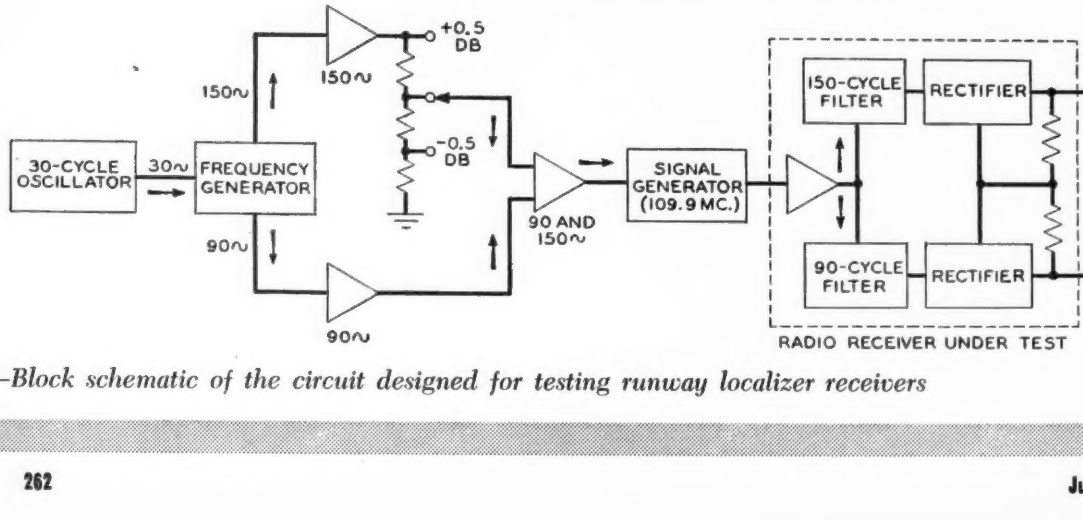


Fig. 2—Block schematic of the circuit designed for testing runway localizer receivers

shunt coil and shunt condenser—L1 and L2, and C3 and C5. The core of the transformer is designed to saturate at a very low current—less than one-third of the peak value—and since as the core saturates, the rate of increase in flux decreases rapidly, the voltage produced—which is proportional to the rate of change of flux—becomes essentially zero well before the current reaches its peak value. Because of hysteresis and eddy currents in the core, the flux is not quite in phase with the current, and may depart considerably from the current curve in shape. Since the principal action involved does not depend on the hysteresis and eddy current losses, but rather on the saturation of the core, the losses may be assumed to be zero in explaining the fundamental action. On this basis, the relations between current, flux, and voltage are as indicated in Figure 5.

At the upper left is the current in the primary of the transformer, and to the right is a plot of flux in the core against current on the assumption of zero loss. At time $t=0$ on the current curve, the current is zero, but increasing at its maximum rate. Since the flux is also increasing at its maximum rate at this point, the voltage will be a maximum, and since the voltage is equal to the negative of the rate of change in flux, it will be at its maximum negative value. This is indicated in the lower curve at the left. Although the flux, following the current, continues to increase, it does so at a decreasing rate, and thus the voltage becomes less negative, and as the current reaches about one-third of its peak value, the rate of increase in flux becomes very small due to saturation. As a result, the voltage becomes essentially zero, and remains so until the flux is brought through the saturation region and begins to decrease rapidly. Then the voltage rises rapidly, reaching a positive peak when the current is zero, and then dropping to essentially zero as the negative saturation is reached. Again it remains zero until the flux has left the region of negative saturation. It then decreases rapidly as the flux increases rapidly and starts another cycle.

As a result of this action, the voltage curve consists of a series of short, alternately positive and negative peaks with

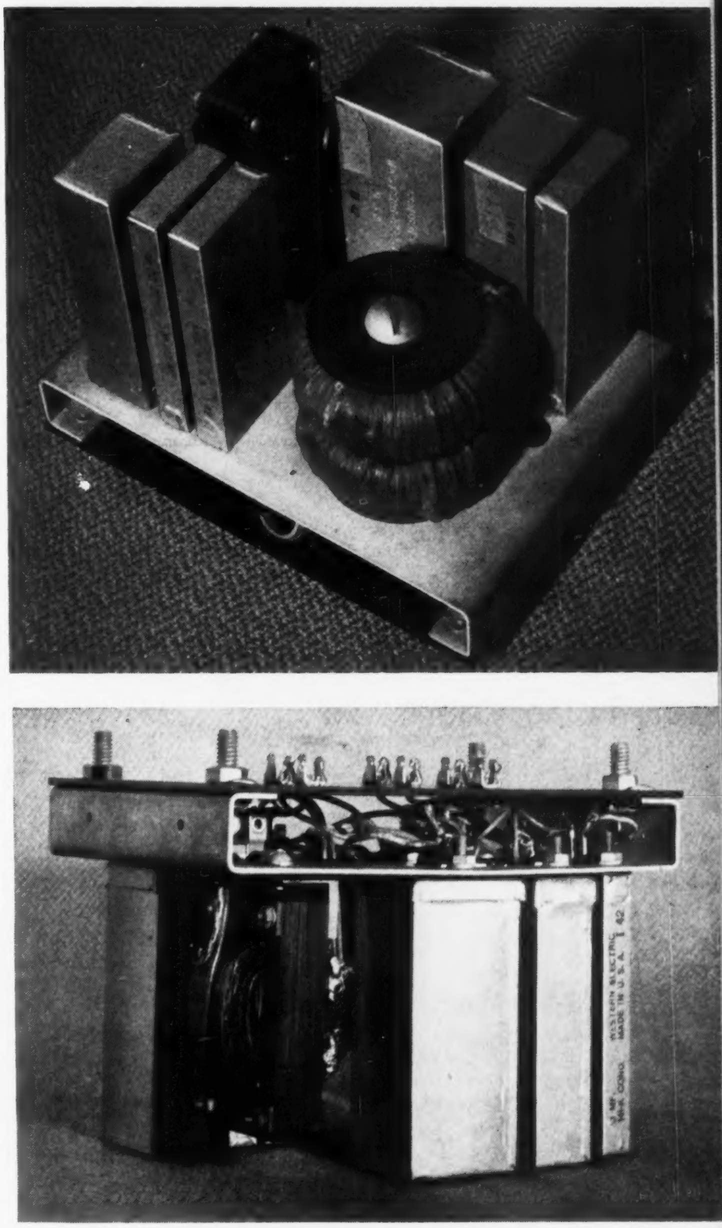


Fig. 3—The coils and condensers forming the frequency generator are mounted on a metal chassis attached to the underside of the cover of the container

relatively long and nearly horizontal sections between them. By Fourier analysis, such a curve may be shown to consist of the fundamental and all the odd harmonics.

During the brief intervals in which the peak voltages occur, condensers C2 and C4 become charged. In the succeeding brief intervals, while the core is saturated and the voltage lies essentially along the zero axis, the inductance of the winding decreases rapidly, and as a result, the con-

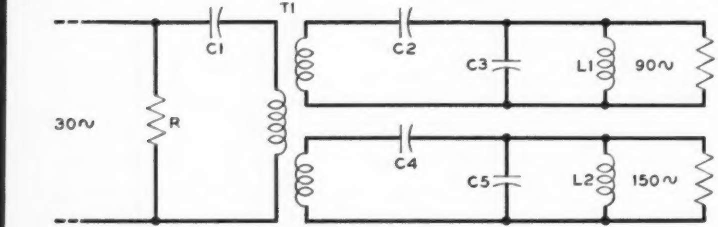


Fig. 4—Frequency generator circuit

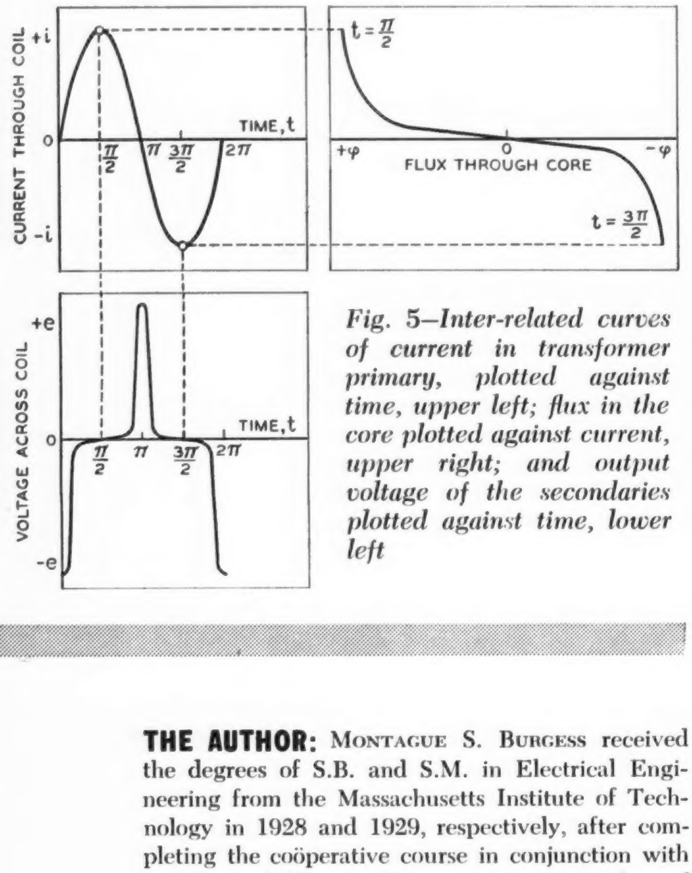
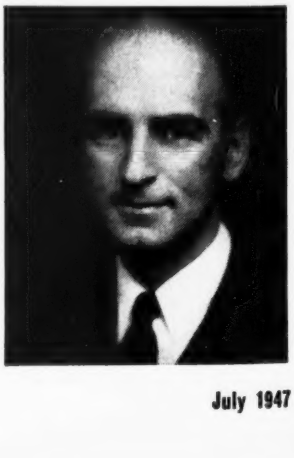


Fig. 5—Inter-related curves of current in transformer primary, plotted against time, upper left; flux in the core plotted against current, upper right; and output voltage of the secondaries plotted against time, lower left

denser discharges through it and the right half of the circuit of Figure 4. Across this right-hand part of the circuit of each winding, however, are coils and condensers tuned to anti-resonance for the output frequency desired from each branch. All the harmonic frequencies in each circuit, except the one to which the tuned circuit is anti-resonant, pass through the tuned circuit, while the two anti-resonant frequencies alone pass through the load.

Harmonic analysis of the outputs of the two branch circuits shows that the undesired 30-cycle component is suppressed from 35 to 39 db below the level of the desired 90- and 150-cycle components. In the 90-cycle output circuit, the 150-cycle component is approximately 18 db below the level of the 90-cycle output, and in the 150-cycle output circuit, the 90-cycle component is approximately the same amount below the 150-cycle output. The maximum peak outputs obtained are approximately 1.6 and 1.2 milliwatts for the 90- and 150-cycle outputs, respectively, when working into a resistance load of approximately 5,000 ohms, which is the impedence of the load in the testing equipment. Although for this circuit only the third and fifth harmonics are selected, additional outputs of the same or higher odd harmonic frequencies could be obtained by increasing the number of secondary windings and inserting the appropriate circuit elements.

THE AUTHOR: Montague S. Burgess received the degrees of S.B. and S.M. in Electrical Engineering from the Massachusetts Institute of Technology in 1928 and 1929, respectively, after completing the coöperative course in conjunction with the General Electric Company. In September of the latter year he joined the Department of Development and Research of the A T & T as a member of the Transmission Development Department, and was transferred to the Laboratories in the 1934 consolidation. His work was concerned with transmission studies relating to carrier and coaxial systems, picture transmission, television and special problems. In 1937 he transferred to Transmission Apparatus Development where he became engaged in the design and development of input and output transformers and repeating coils for carrier and radio frequencies. In 1941 he transferred to the power transformer design group where he has been concerned with the development and construction of high and low voltage transformers and retardation coils used in regulated rectifiers, aircraft, and radar equipment. He has also designed and developed several types of static frequency generators using non-linear magnetic coils.



H. S. BLACK
Transmission
Development

PULSE CODE MODULATION

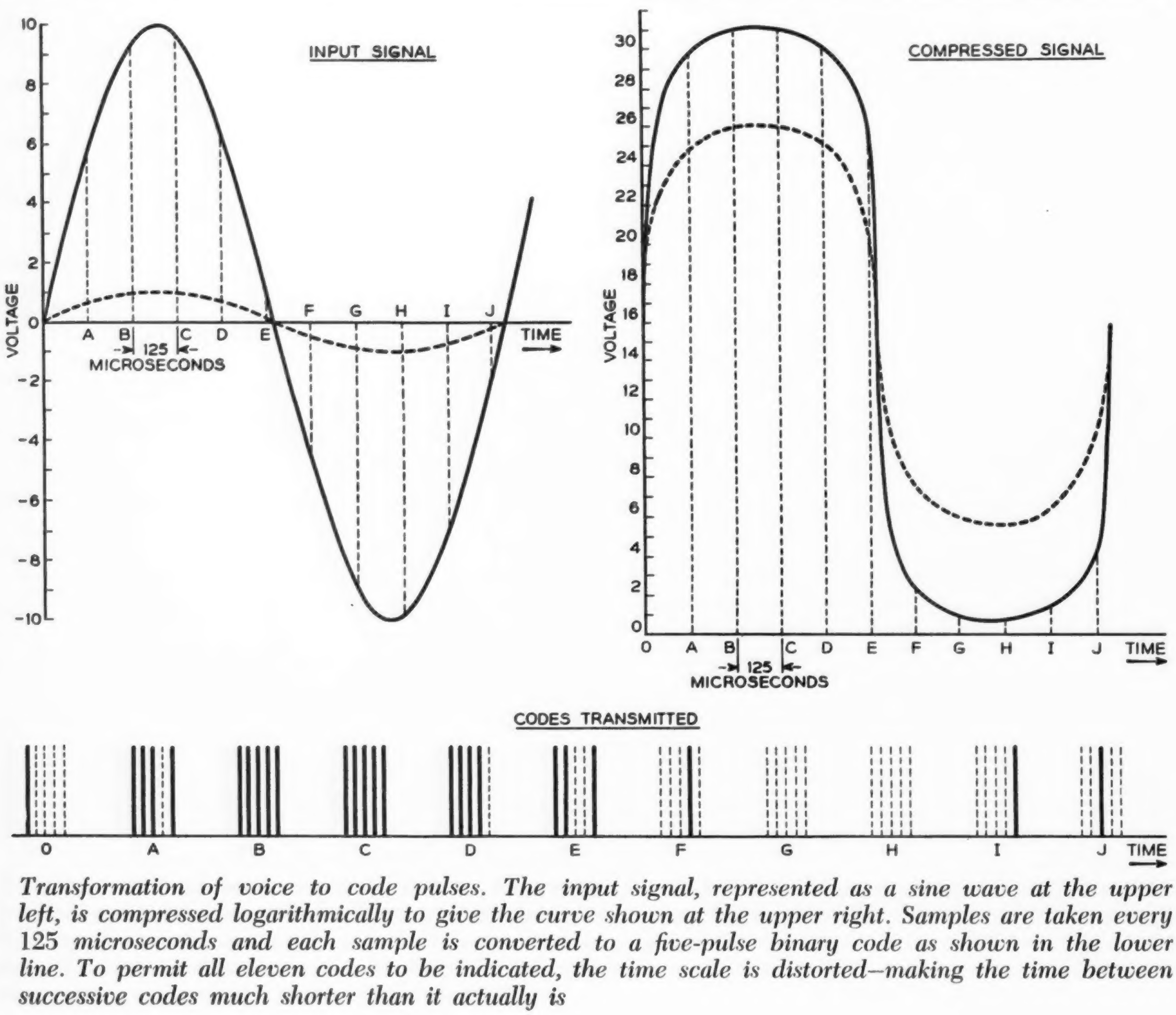
A new technique for long-distance multichannel telephony has been developed that is capable of unusually fine fidelity and is entirely undisturbed by all but abnormally high noise. Theoretically, the value of the peak noise may be nearly equal to the peak signal. With this new system, employing a procedure known as pulse code modulation, the voice is transmitted as a sequence of on-or-off pulses, which are coded to represent the values of the signal at regularly spaced short intervals. It lends itself readily to multiplexing by time division, and thus will permit a single circuit to provide a number of channels. Pulse code modulation requires extra frequency space, and at present seems particularly adapted for transmission over microwave radio-relay systems. An eight-channel system employing these principles was produced, and gave very satisfactory transmission and exceptional freedom from interference during extensive and rigorous trials. Other work carried on simultaneously by W. M. Goodall, Radio Research, resulted in the development of an experimental system using a different method of coding. Pulse code modulation by another method is proposed in a U. S. patent issued to A. H. Reeves and assigned to International Standard Electric Corporation.

One of the major problems of telephone transmission has been the reduction of noise and distortion that is picked up along the path or introduced by associated equipment. Up to the present time, noise and distortion has remained a controlling factor in long-distance transmission. This is principally because of the cumulative building up of noise and other transmission impairments with each of the many amplifications necessary over long distances.

The development of pulse code modulation, commonly referred to as PCM, makes it possible to remove noise and distortion as a limiting factor by basing the reconstruction of the continuous message wave at a receiving station on the arrival or failure to arrive of pulses, nothing more. At every repeater point in a PCM system, simply this presence or absence of pulses is all that is required to permit the message to be regenerated and given a fresh, noise-free start. In a well-designed PCM system, there should be practically no transmission impairment due to adding repeaters. Except for a small delay, chiefly due to the finite velocity of propagation, the code characters delivered by the last repeater correspond to the code input at the sending end, and thus will convey the identical intelligence carried by the code output of the first transmitter.

At any instant the voltage produced by a telephone transmitter may be positive or negative as the pressure of the acoustic wave becomes greater or less, and because of the rapidly changing character of speech, with its irregular and complex intonations, and because the resulting voltage may have any of an infinite number of values between the plus and minus limits fixed by the system, it might seem impossible to substitute a simple sequence of coded on-or-off pulses for it. Conversion of voice to coded pulse signals is possible, however, by use of two principles: sampling and quantizing.

It was shown many years ago that if a signal is sampled instantaneously at regular intervals and at a rate slightly higher than twice the highest signal frequency, then the samples will contain all of the information of the original signal. This means that



Transformation of voice to code pulses. The input signal, represented as a sine wave at the upper left, is compressed logarithmically to give the curve shown at the upper right. Samples are taken every 125 microseconds and each sample is converted to a five-pulse binary code as shown in the lower line. To permit all eleven codes to be indicated, the time scale is distorted—making the time between successive codes much shorter than it actually is

if a voice wave were plotted, it could be reproduced in all its detail from the values of a set of ordinates erected at equally spaced intervals provided the separation of the sampling ordinates be not greater than half the period of the highest component frequency of the original wave. If a voice wave, for example, is passed through a low-pass filter whose cut-off frequency is below 4,000 cycles, all of the information necessary for its distortionless reconstruction is contained in a set of very short samples of the voice wave taken at regular intervals at the rate of 8,000 per second. No intrinsic distortion is involved. This sampling principle was used in the microwave relay system using pulse position modulation already described.*

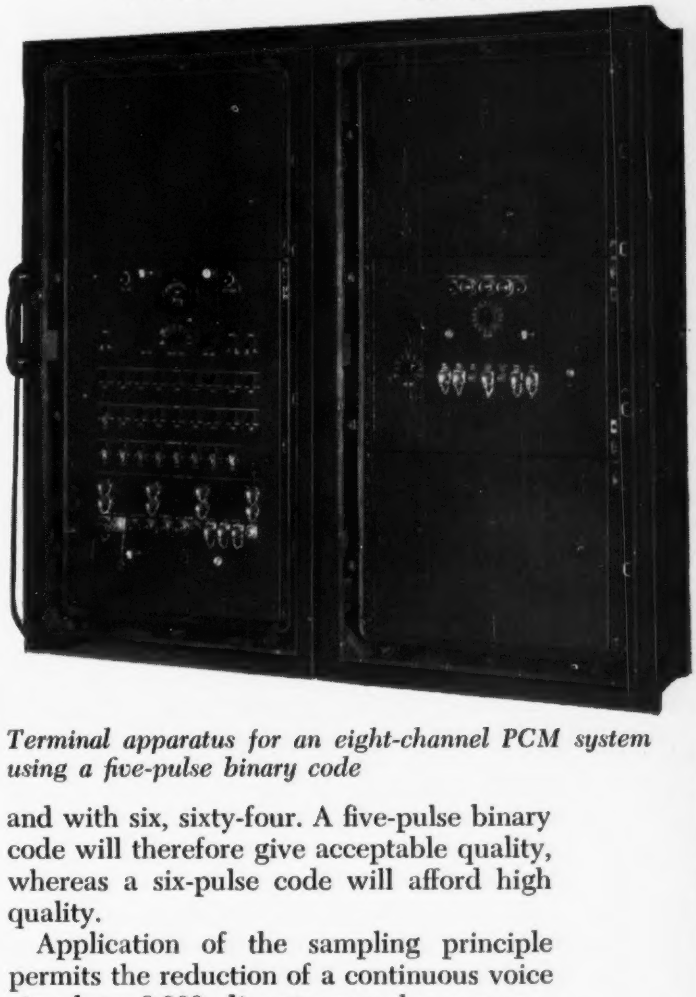
Application of the sampling principle reduces the problem to one of sending a finite number of bits of information giving the values of the samples of the voice wave. However, the complete translation problem still is not solved because the samples may and generally will occupy a continuous range, and thus an infinite number, of values. This difficulty is resolved by a second step: the application of the quantizing principle to the samples obtained.

*Record, *December*, 1945, *page* 457.

If one experimenter were obtaining points on a curve and calling them to a second person for plotting on a graph, it would be necessary for them to agree on the precision with which they must work. If they agreed to use two significant figures, for example, they might choose coordinate paper with 99 lines above and 99 below the axis. Each point then would be plotted on one of these lines. Those experienced in curve plotting would expect to obtain a good likeness to the original smooth curve in spite of the fact that only 199 possible discrete values of sample had been used.

The quantizing principle states that each of a set of small ranges into which a larger range may be divided is assigned a single discrete number or character, such as that corresponding to the mean of the range. In the example above, any value from -0.5 to $+0.5$ would be called zero, or any value between 94.5 and 95.5 would be called 95. It is quite apparent that some distortion or granularity is inherent in the application of the principle of quantization to an electrical signal carrying the information of the spoken word. The greater the size of the range assigned to a given character and the fewer characters used, the greater will be this granularity. The problem then is to determine the smallest number of steps into which voice signals may be quantized without serious distortion, and what should be the size of each step.

The range of voltages covered by voice signals, from the peaks of a loud talker to the weak passages of a weak talker, is roughly of the order of a thousand to one. If the range of voltage assigned to each code character were small enough to keep the granularity within the desired limits, and if the range assigned to all characters were the same, it would be necessary to assign about a thousand characters to cover the full voltage range. By making the steps vary approximately logarithmically, nearly uniform percentage precision is obtained throughout most of the range and far fewer steps are needed. It has been found by experience that sixteen steps which vary logarithmically give quite intelligible speech; that thirty-two give acceptable quality even if several such systems are connected in tandem; and that the granularity introduced by a well-designed system using 64 characters is little enough so that the reconstructed speech wave is reproduced to a high degree of fidelity as judged by experienced observers. With simple on-or-off pulses, the number of available characters is equal to 2 raised to a power equal to the number of pulses comprising the code. Thus with four pulses per character, sixteen characters are possible, with five pulses, thirty-two characters, and with six, sixty-four. A five-pulse binary code will therefore give acceptable quality, whereas a six-pulse code will afford high quality.



Terminal apparatus for an eight-channel PCM system using a five-pulse binary code

Application of the sampling principle permits the reduction of a continuous voice signal to 8,000 discrete samples per second, and application of the quantizing principle permits each sample to be represented with sufficient accuracy by coded characters that use the various combinations of five or six on-or-off pulses.

Pulse code modulation also permits multiplexing the channels by time division. If the pulses are short, so that the five or

six on-or-off pulses comprising one character can be sent in a small fraction of the 125-microsecond interval between characters, the clear time may be occupied by code pulses from other voice channels, thus permitting multiplex operation with many channels.

How the sampling and the quantizing principles permit a voice frequency wave to be transformed to a sequence of pulse codes is indicated in the diagram on page 266. At the upper left are shown two sine waves which may be assumed to represent in idealized form the highest volume signal to be transmitted and a lower signal. The sampling points, spaced 125 microseconds apart, are indicated by dashed lines and marked O, A, B . . . J, inclusive. It is the voltage values of the original wave at these points, after they are quantized to a logarithmic scale and then coded, that are to be transmitted. Since the values of the samples to be transmitted are on a logarithmic scale, the voice wave may be passed through a logarithmic compressor to give the curve at the upper right. It will be noticed that the effect of this compression is to increase the relative values of the low voltages and to decrease those of the high voltages. For the graph at the upper right the ordinate scale, instead of extending to positive and negative values from a zero axis, starts from the bottom of the negative loop of the highest volume signal to the top of the positive loop of the same signal, and the intervening distance is divided into thirty-two equal spaces marked from 0 to 31 on the diagram. A value of signal falling anywhere within the limits of the No. 4 space, for example, is transmitted as a 4 in binary code.

Along the horizontal time axis below the two curves are the eleven code patterns that would be transmitted to represent the values of the eleven samples as obtained from the curve at the upper right. A solid line is used to indicate a pulse, and a dotted line, the absence of a pulse. To permit all eleven codes to be shown across the width of the page, it has been necessary to distort the time scale. Actually the codes are spaced 125 microseconds apart since the samples are taken at the rate of 8,000 characters per second, while each code itself requires only about 16 microseconds. On a true time scale there is space for the codes for eight channels.

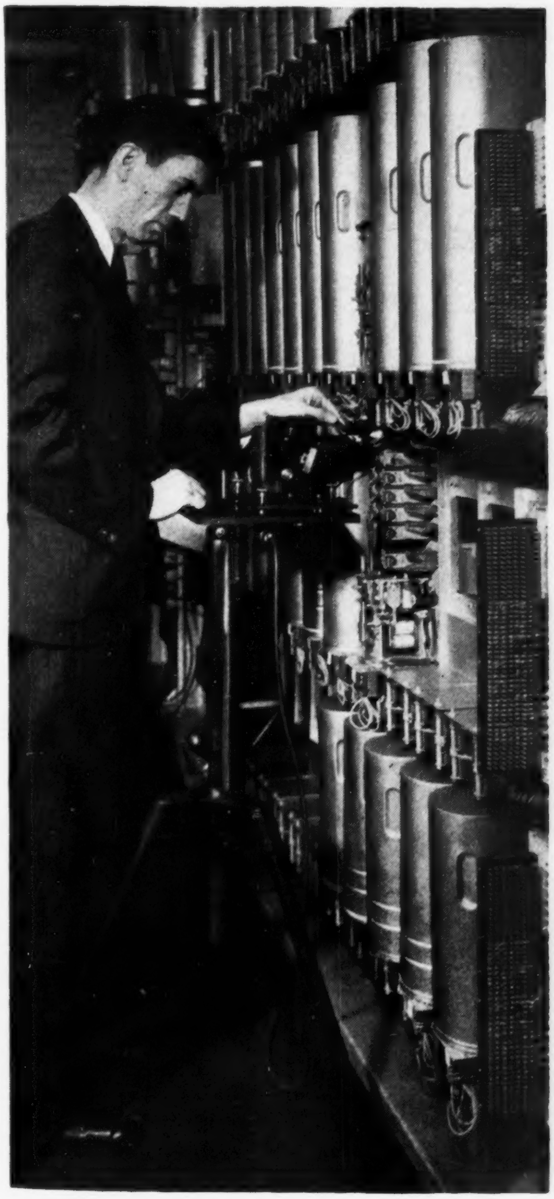
A single-channel PCM system carrying speech runs at 8,000 characters per second, and the eight-channel system mentioned earlier, shown in the photograph on page 267, runs 64,000 per second. The

THE AUTHOR: H. S. Black received the B.S. degree in Electrical Engineering from Worcester Polytechnic Institute in 1921, and at once joined what is now Bell Telephone Laboratories. In 1925 he was placed in charge of a group developing repeaters, regulators, filters, and other circuits for carrier telephone systems, and later invented the stabilized feedback amplifier, which has come into general use not only with carrier systems but with radio broadcasting and other electronic and communication fields both here and abroad. He also proposed the use of thermistors for the regulation of telephone circuits. In 1934 Mr. Black received the A.I.E.E. prize for the best paper in Theory and Practice for his paper on *Stabilized Feedback Amplifiers*. In 1940 he was honored by the National Association of Manufacturers as a Modern Pioneer, in recognition of distinguished achievement in the field of science and invention. In 1941 The Franklin Institute of Philadelphia awarded him the John Price Wetherill medal for his technical contribution to the modern efficiency of long-distance telephony. During the war period, Mr. Black was concerned almost exclusively with secret war developments. Since that time he has been engaged largely in studies and designs of radio pulse relay systems.

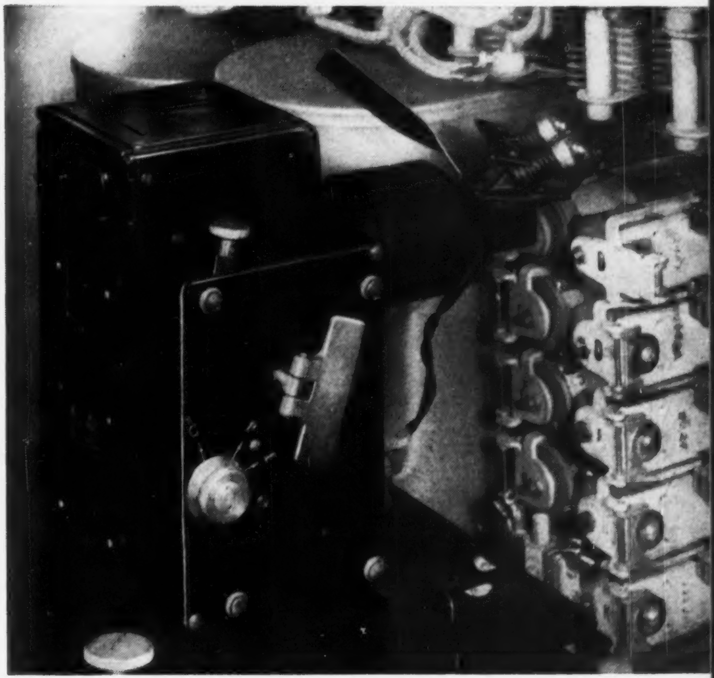
pulsing speed is 8,000 x 8 x 5, which is 320,000 on-or-off pulses per second. It is apparent that high-speed electronic devices must be used to attain such speeds of operation. Surprisingly large numbers of possible devices have been proposed, ranging from standard types of vacuum tubes to more complex structures, and many of them have been tried out experimentally.

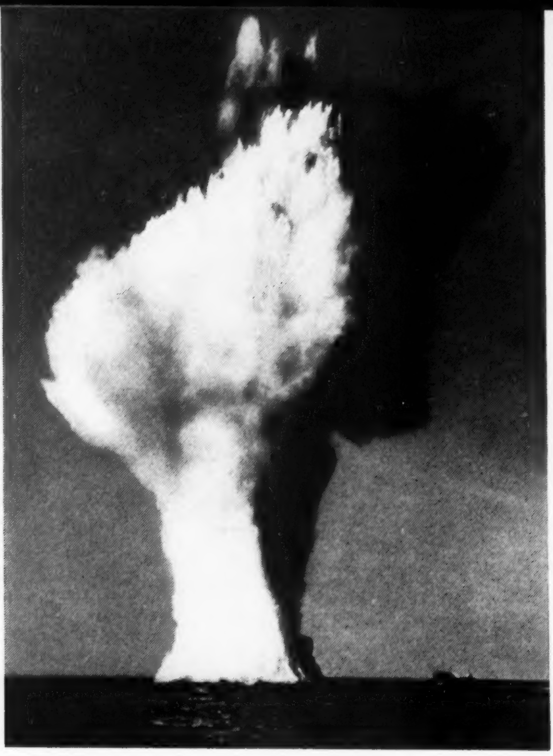
Pulse code modulation appears to have exceptional possibilities in its freedom from interference especially when applied to systems having many repeaters in tandem, but its full significance to the radio and wire transmission of the future may take some time to reveal.

Precision Measurement Made From Projected Negatives



The special camera equipment shown in these two illustrations was developed by the photographic engineering group of the Apparatus Development Department for recording adjustments of step-by-step wipers on banks under operating conditions. Photographs have been taken both at Hawthorne and in central offices under field conditions which permit precision measurements to be made from the projected negatives. At the left, J. H. Waddell is shown operating the camera.





MAGNETIC MINE FUSE MECHANISM

H. O. SIEGMUND
Switching
Apparatus
Engineer

During the war, Bell Telephone Laboratories carried on extensive development work for the Armed Forces on proximity fuse mechanisms for ordnance devices, such as projectiles, rockets, bombs, naval mines, and depth charges. Some of these devices utilized photoelectric effects, and a fuse of this kind for use with 4.5-inch rockets was recently described.* Some operated on the Doppler effect with short-wave radio, and some on the disturbances of the earth's magnetic field produced by the presence of ships. The work on fuses for magnetic mines has been an important part of this work in which the extensive knowledge and long background of experience with magnetic alloys, particularly permalloy, have been of the utmost importance. It was most fitting and appropriate in this connection that G. W. Elmen, the inventor of permalloy, should have been called out of his Bell Laboratories' retirement by the Navy to work at the Naval Ordnance Laboratory on magnetic mine fuses. He was actively connected with the Navy's development program on magnetic mine fuses, and throughout the war he worked closely with our Laboratories' engineers similarly engaged. Mr. Elmen had three other retired Bell Laboratories' employees as associates at the Naval Ordnance Laboratory on mine fuse work—J. F. Toomey, E. Montchyk, and J. N. Reynolds.

Naval mines are important offensive weapons. This is particularly true in connection with mines laid from airplanes in enemy waters. The magnetic mine, equipped with its associated proximity fuse mechanism, which was designed by the Laboratories and manufactured in large quantities by the Western Electric Company, was the most modern magnetic mine of the United States Navy during the war. When a steel vessel passes over this mine, the steady magnetic field of the earth surrounding the mine is altered, first shifting slowly away from the normal steady condition as the ship approaches, and then drifting back to normal as the ship recedes. The fuse

*Record, *February,* 1947, *page* 70.

mechanism recognizes the passing ship whenever it detects a magnetic disturbance with this characteristic slow reversal of the flux change, and causes an explosion when the ship is over the mine. The mine is provided with anti-sweep features, protection for countermining, and is equipped with a mechanical memory so that it may be set to blow up a certain numbered ship in a convoyed train rather than to take the first one.

The vital elements of the mine fuse are the search coil that detects the feeble magnetic influence of an approaching ship, and the magnetic amplifier which increases the strength of the feeble detected signal about a million times. Both the search coil and the magnetic amplifier require permalloy of extraordinary quality and precise manufacture to operate satisfactorily.

Although as sensitive as the most delicate jeweled instrument, the electronic mine fuse is constructed very ruggedly. Mines equipped with these fuses may be dropped into the sea from airplanes several thousand feet in the air. In fact, this fuse was used successfully in mines laid by planes from altitudes up to 30,000 feet in a free fall without parachutes. These free-falling mines could be aimed more accurately because the drift without parachutes was much less. Tests on fuse mechanisms at proving ranges where it was possible to retrieve the mines have disclosed that this mechanism retains its sensitivity and required operating characteristics after it had been dropped in free falls from heights of several miles. In one case, a test mechanism without explosive charge dropped from over 10,000 feet, struck the shore instead of the water, and although the mine case broke and the contents were strewn over a considerable area, the fuse mechanism was intact and was found to operate as well as ever after this rough treatment.

After a mine is dropped into the water, it is made alive by the usual arming devices and begins to search for the presence of ships. As a ship approaches, the change in the earth's field generates a voltage in the search coil, and the resulting signal current upsets a delicate balance in the magnetic amplifier circuit, firing the mine.

Magnetic mines with proximity fuse mechanisms were used in operations that cut Japanese life lines and throttled her shipping-dependent economy at the close of the war. This strategic mining blockade, called "Operation Starvation," was undertaken late in March of 1945. The ports of Kure, Hiroshima, Tokayama, Sasebo Naval Base, and Shimonoseki were mined by superfortress to prevent Jap naval units from participating in the defense of Okinawa. The blockade was extended later in the campaign to major shipping lanes between industrial cities which depended largely on water transportation for their goods. Shipping was cut to 10 per cent of normal within two months. Heavily used and direct shipping routes to the continent of Asia were then severed by mining the ports of northwestern Honshu.

The final phase of the operations was an intensification of the existent blockade around major shipping centers in Japan, plus additional mine laying in Fusan and other Korean ports. During this final phase, the tonnage of Japanese shipping that was sunk by mines has been estimated to exceed 300,000 tons.

The development of magnetic mine fuses at Bell Laboratories was carried out under contract with the Navy Bureau of Ordnance. The work was done in close coöperation with the Naval Ordnance Laboratory. In making an appraisal of mine operations by our naval fighting forces, Admiral Nimitz has said:

"The technical planning and operational execution of aircraft mining on a scale never before attained has accomplished phenomenal results and is a credit to all concerned."

Japanese naval authorities have had the following to say about the mine fuse mechanisms of the United States Navy, as reported in a publication of the Naval Ordnance Laboratory:

"The detonators show superior construction and speak well of the ability of the specialists and the manufacturers. Furthermore, the application of new fundamental principles to mines shows the skill and farsightedness of the technical experts which was far beyond that of those in Japan at the time. That is to say, the mine

LABORATORIES' MAGNETIC MINE FUSE GROUP

Front row, left to right: F. L. McNair, J. M. Hinkle, G. Crabb, H. L. Messerschmidt, H. M. Knapp, E. G. Walsh and G. Angell. Middle row: F. A. Zupa, L. J. Steinbach, Jr., H. N. Wagar, Margaret Jaeger, K. H. Schunke, J. E. Walker and J. A. Ashworth. Rear row: H. O. Siegmund, R. M. Bozorth, B. F. Runyon, M. A. Logan, V. E. Legg, F. W. Goss, J. Edgeler, R. F. Glore, C. E. Rooney and T. Cuff

fuse . . . circuit using a small type of glow tube (cold cathode tube developed by the Bell Telephone Laboratories and manufactured by the Western Electric Company) is indeed a clever idea.

With respect to earlier mine fuses on which the Laboratories did extensive development work with the Naval Ordnance Laboratory and the Leeds & Northrup Company, the following was said by the Japanese experts:

"It is clear that these detonators are an application of designs by telephone communication engineers, and the fact that they were perfected with telephone materials speaks well for those specialists in the application of their knowledge. There were no mine technicians in Japan comparable to those in America, and the display of such ability by America was the occasion for surprise among the mine specialists in the Japanese Navy."

THE AUTHOR: H. O. SIEGMUND, Switching Apparatus Development Engineer, received a B.S. degree from the University of Illinois in 1917 and an E.E. degree in 1926. After service in the Aviation Section of the Signal Corps during World War I, he taught physics and electrical engineering at Drexel Institute; he then came to West Street in 1919. His work has been concerned principally with the development of telephone apparatus, first in connection with aluminum electrolytic capacitors and filters to reduce background noise and improve transmission in telephone circuits, and then in connection with panel, step-by-step and crossbar switching apparatus, ringers and dials. During World War II he was project engineer on proximity fuse developments for underwater ordnance and for rocket developments, and was concerned with work on sonar, radar, and fire-control systems. Since the end of the war he has again taken charge of work on switching apparatus development.

J. A. POTTER
Power
Development

SHUNT TUBE CONTROL FOR THYRATRON RECTIFIERS

Cathode-ray oscilloscopes used as indicators for radar apparatus during the war indicate the distance to enemy planes or ships by short "pips"—small deflections of the scanning spot as it travels across the face of the "scope." These pips are caused by small changes in voltage, and if erroneous indications were to be avoided, it was essential that the basic power supply be kept free from sudden changes in voltage, even though they were comparatively small. For the early radars, satisfactory regulated rectifiers of a type already described* could be provided, but as radars of considerably higher power were developed, the requirements for the rectifiers could not be met economically by existing types. Rectifiers that would eliminate small sudden changes in voltage were not economical in the larger sizes, while those that were economical for larger currents would pass brief voltage swings. Since larger currents were essential, and since even a very brief voltage fluctuation may be noticeable on a radar scope, a different type of regulator was required. It was this type of need that led to the development, during the war, of the shunt tube control for thyratron rectifiers.† It was used, for example, in the M-9 director, in certain of the microwave communication systems, and in many of the Navy fire-control radars.

Since output voltage may be controlled by very small changes in voltage applied to their grids, thyratrons make highly satisfactory regulated rectifiers, but they have a small inherent lag that prevents the elimination of brief, steep-front voltage changes by changes of their grid bias. For any one value of grid voltage, they start to pass current at one particular value of the wave of the applied voltage; but once they start to pass current, interruption is not again possible until the applied voltage reverses. With a full-wave thyratron-regulated rectifier, the possible output current is represented by the dashed half waves of Figure 1, where the first half cycle is the current from one tube, the next half cycle that from the other, and so on alternately. With the grid voltage such that the tubes start to pass current at t_1, the output current, and hence the voltage, is proportional to the shaded area under the current curve. When the output voltage increases, and thus requires adjustment downward, the grid voltage is automatically adjusted so that for succeeding cycles the current starts at some later point, such as t_2. This will decrease the shaded area and permit precise control of the output voltage averaged over a time interval representing several input cycles.

But suppose that the tube starts to pass current at t_1, and that immediately afterward the voltage suddenly rises. Since the tube has already started to pass current, no change in the output current can be made for the remainder of the half cycle. It will not be until t_3 that grid control can act to limit the current passed by the thyratrons. There may be an interval of the order of eight milliseconds—the duration of a half cycle of sixty-cycle voltage—during which grid control is impossible. Although the regulating circuit may have acted promptly to change the grid voltage to the desired value, the thyratrons cannot change their behavior until the next half cycle. There is another inherent delay in

*Record, *May*, 1937, *page* 298.
†U. S. Patent No. 2,377,370.

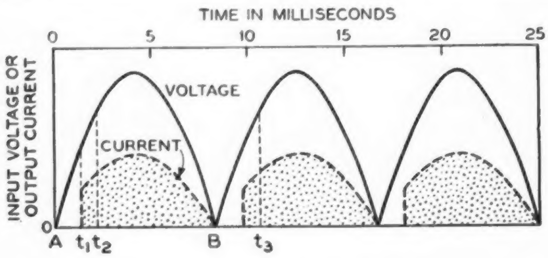


Fig. 1—Plot of input voltage and output current for thyratron rectifier

the previous rectifiers due to the filter circuit, which opposes an instantaneous change in current. Both of these delays, however, are overcome with the shunt tube control by connecting the plate circuit of a vacuum tube across the load. By allowing the regulating circuit to change the bias of the grid of this tube so as to adjust the amount of current it passes, small brief changes in current are passed by this tube without flowing through the filter or thyratron. The circuit in simplified form is shown in Figure 2. When the output voltage rises, the regulating circuit immediately adjusts the grid bias of the shunt tube to make it pass more current, and this added load current causes a voltage drop across the impedance of the rectifier circuit almost sufficient to wipe out the original rise. A small residual rise is essential, of course, to operate the regulating circuit. This reaction takes place in an extremely short time interval—before the thyratrons have had time to respond. A resistance is placed in the plate circuit of the shunt tube, and the voltage drop across this is used to adjust the bias of the thyratrons for the new conditions.

The thyratrons themselves react only to the average load. A resistance-capacitance filter in the circuit between the thyratron grids and the plate resistance of the shunt tube represses the line frequency and higher frequencies, and thus the bias of the thyratron grids varies only with the average current through the shunt tube. All more rapid variations are absorbed by the shunt tube or by the main filter condenser, shown at the extreme right.

Current through the shunt tube adds to the load current, of course, and to this extent decreases the efficiency of the circuit. It has been found, however, that a shunt current less than ten per cent of the load is adequate for regulation under most conditions, and the moderate loss this causes is more than outweighed by the improved regulation obtained.

In the regulating circuit, a bridge network with fixed resistors in three arms and a diode in the fourth supplies a grid voltage for an amplifier tube that in turn furnishes grid bias for the shunt tube. In somewhat simplified form, the schematic for one type of regulator is shown in Fig-

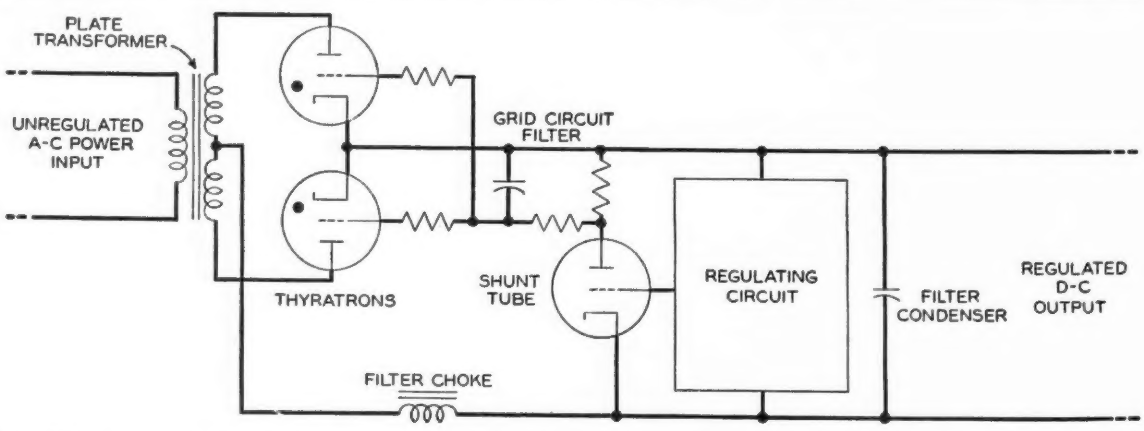


Fig. 2—Simplified circuit of shunt tube control for a thyratron rectifier

ure 3. The input corners of the bridge are connected across the regulated d-c output, while the galvanometer corners are connected so as to furnish the grid voltage of the amplifier. The output of this amplifier is applied to the grid of the shunt tube. A potentiometer at the bridge corner between R1 and R2 permits initial adjustment for variations that might arise during manufacture.

The voltage drop across the diode of the bridge circuit remains constant regardless

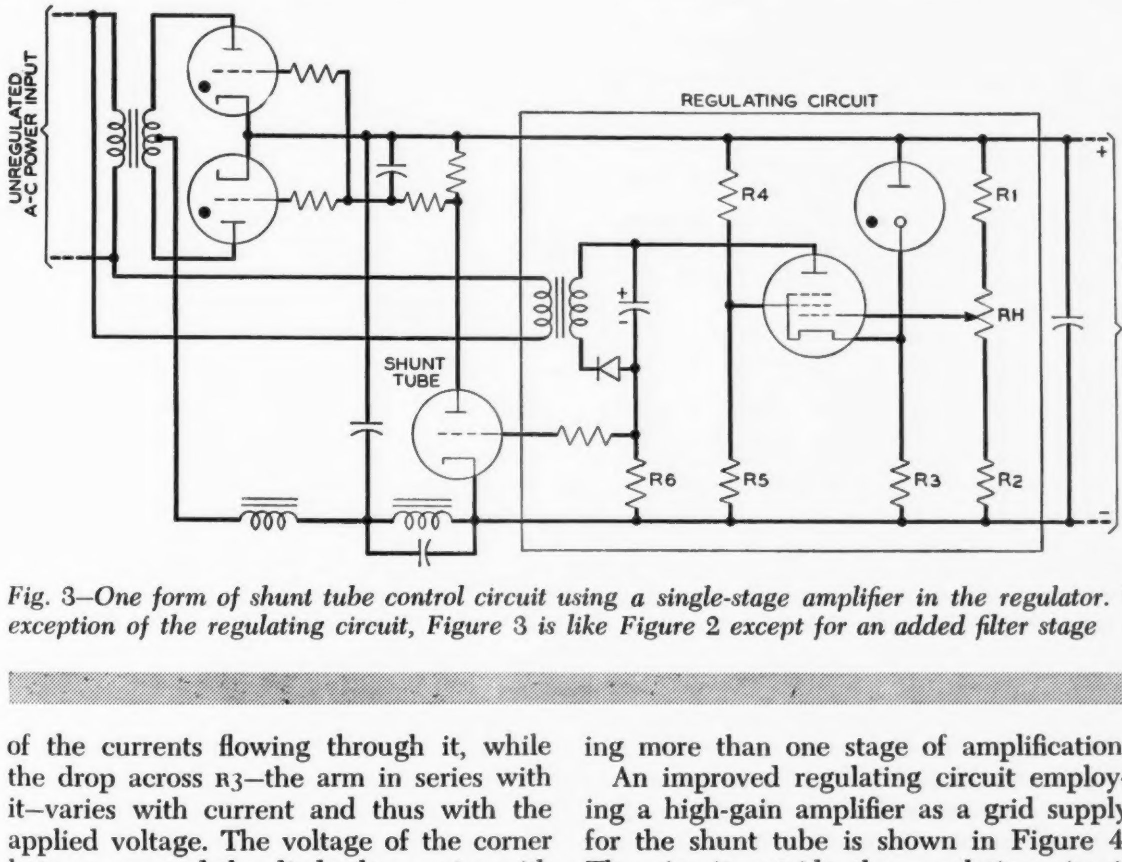


Fig. 3—One form of shunt tube control circuit using a single-stage amplifier in the regulator. With the exception of the regulating circuit, Figure 3 is like Figure 2 except for an added filter stage

of the currents flowing through it, while the drop across R3—the arm in series with it—varies with current and thus with the applied voltage. The voltage of the corner between R3 and the diode thus varies with the regulated voltage, and it is this voltage change that is amplified and applied to the shunt tube. Plate supply for the amplifier is obtained from a winding on the power transformer through a selenium rectifier and a filter condenser. Outside of the regulating circuit, Figure 3 is like Figure 2 except for an added filter stage.

A variety of regulating circuits of the shunt type has been used, and various auxiliary schemes have arisen for obtaining special performance features. Line-voltage and load-current change compounders consisting of simple resistance networks have been devised to improve regulation in typical rectifiers. Where a single shunt tube does not provide the desired dynamic response, two or more shunt tubes may be operated in parallel. In general, the higher the gain in the regulating circuit, the more closely can the output be regulated; and where this additional gain is needed, it may be supplied in the regulating circuit by using more than one stage of amplification.

An improved regulating circuit employing a high-gain amplifier as a grid supply for the shunt tube is shown in Figure 4. The circuit outside the regulating circuit is the same as in Figure 3 except that the series element in the added filter stage is a resistor instead of a tuned inductance for the sake of economy and to improve shunt tube effectiveness over a wider range of ripple suppression. Equipments of this type may be depended upon to vary from the output voltage setting less than 0.25 per cent with the fluctuations in operating conditions encountered in military service. The component of ripple voltage present in the

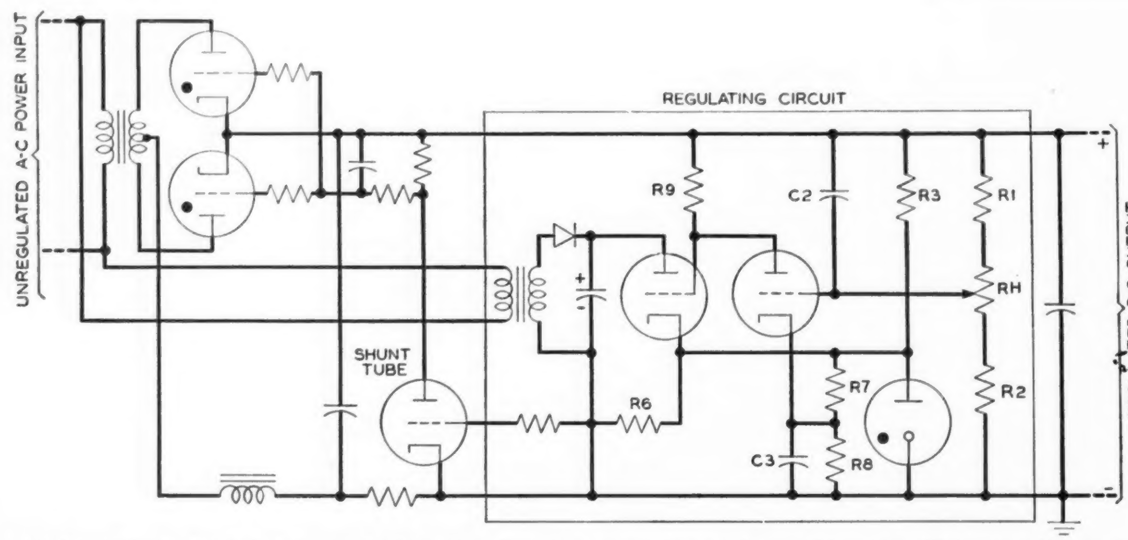


Fig. 4—An improved shunt tube regulating circuit using two stages of amplification. This circuit, outside of the regulating circuit, is the same as Figure 3 except that the series element in the added filter stage is a resistor instead of a tuned inductance for the sake of economy and to improve shunt tube effectiveness over a wider range of ripple suppression

output is less than 0.01 per cent. The nonlinear bridge circuit configuration here differs from that of Figure 3 by the location of the diode and the addition of two resistors R7 and R8. These two resistors are used for the purpose of dividing the reference voltage potential across the diode. This potential provides a suitable voltage for the cathode of the first amplifier stage.

The thyratron itself is an efficient regulated rectifier; and when shunt tube control is added to it, rapid regulating response to abrupt changes in line voltage and load current, and a high degree of ripple suppression, are secured at no more than a moderate penalty in efficiency.

THE AUTHOR: J. A. Potter graduated with honors from the Georgia School of Technology with a B.S. degree in E.E. in 1937. He then joined the Systems Development Department as a member of the Technical Staff, where with the central-office equipment group he first worked on field installations and current analyzation. Later he transferred to the power group where he has been concerned with regulated rectifiers, electronic timers, voltage regulators, and servo mechanisms.

W. WEST
British
General
Post Office

RESEARCH WORK IN THE BRITISH GENERAL POST OFFICE

The General Post Office of Great Britain supplies to the public a variety of services, of which the telephone and telegraph services make by far the greatest demands on the Engineering Department. The organization of the Post Office is on a regional basis, general direction to Regions being through Headquarters Departments centered in London (St. Martins-le-Grand). Of these, the Engineering Department, in the charge of the Engineer-in-Chief, assisted by the Deputy Engineer-in-Chief, the Controller of Research and two Assistant Engineers-in-Chief, is divided into a number of Branches, each in the charge of a Staff Engineer. Each Branch deals with a specialized functional division of the Department's work such as Telegraphs, Motor Transport, Staff, Radio Development, Transmission and Lines, etc. There are at present eighteen Branches, but the number varies according to the incidence of work on the Department. The duties of the Branches include responsibility for any engineering development (within their functions) of the systems and apparatus that are used by the General Post Office.

The Research Branch is rather larger than many of the other Branches and is directed by the Controller of Research, who, besides being responsible for all engineering and scientific research carried out by the Post Office, is also responsible for coördinating the work of the Research Branch with the development work of other Branches. In this respect he is assisted by a departmental committee comprising the heads of Branches responsible for development work.

Most of the Branches in the Engineering Department have offices in the City of London, but the Research Branch has its laboratories in the suburb of Dollis Hill, about 7 miles distant. Other Branches concerned with development have laboratory facilities appropriate to their own specialized work—notably the Radio Development Branch, whose experimental sections share the premises of the Post Office Engineering Research Station at Dollis Hill with the

Main research building of the British General Post Office

Research Branch. The General Post Office as a whole provides services for which, with a few exceptions, it obtains the necessary plant and equipment by purchase from manufacturing companies, of whom it is not the sole customer. The development work which precedes the production of new types of equipment may therefore be done either by the Post Office, in which case the Engineering Department prepares a detailed manufacturing specification to which the equipment is bought, or by one of the manufacturing companies, generally to a performance specification issued by the Post Office. Not unusually, the final product is the result of coöperation between the Post Office and the manufacturing company.

The development for manufacture of telephone exchange equipment and subscribers' apparatus for the Post Office is coördinated by a committee, known as the British Telephone Technical Development Committee, with representatives of the Post Office and of the principal companies manufacturing this class of equipment. A differentiation is here made between development for manufacture and development for service, which latter is more exclusively the function of the organization

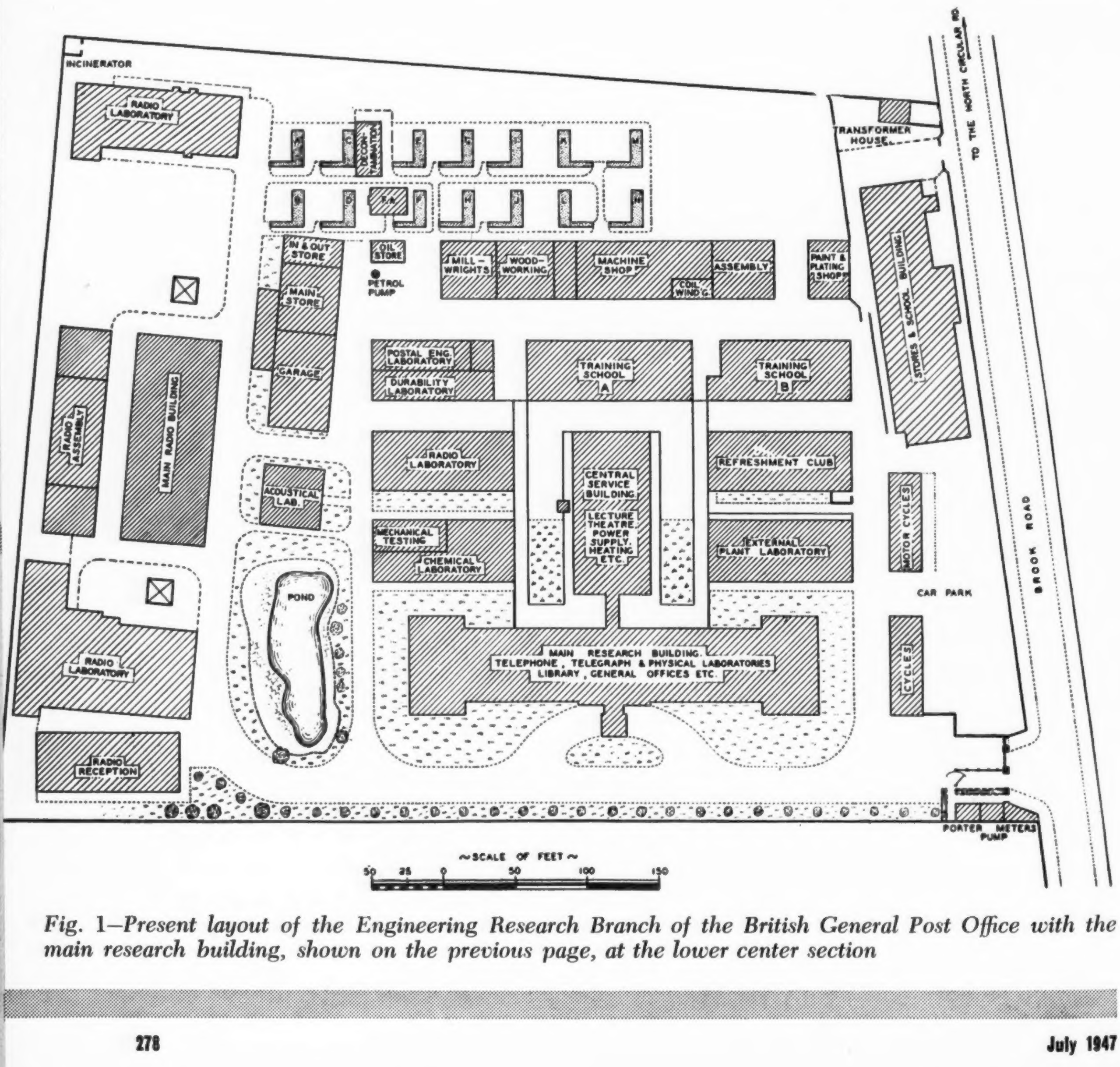


Fig. 1—Present layout of the Engineering Research Branch of the British General Post Office with the main research building, shown on the previous page, at the lower center section

Fig. 2—Laboratory devoted to the development of central-office switching systems

which supplies the service. For example, for the maintenance of service, routine and special tests have to be made on telephone plant; devising new tests to be made can be regarded as a service development, while production of new types of testing equipment requires manufacturing development. The Research Branch may be consulted on either or both of these developments and, if a new design of equipment results, models would be made at the Research Station for field trial and, if several complete sets of equipment are needed, for putting out for manufacture.

Before and during World War I, experimental work was carried out in very limited accommodation at the City Headquarters. In 1921 the work was transferred to the present site, about eight acres in extent, at Dollis Hill. One of the factors governing the choice of the site was the relative absence of noise and vibration by rail and road traffic—a consideration of more importance in the days of dependence on the use of very sensitive mirror-type galvanometers for electrical measurements than it is today.

Initially, accommodation for offices and laboratories was in Army-type wooden huts which were in due course replaced by permanent buildings of brick. By 1933, when the Research Station was formally opened by the then Prime Minister (Ramsay MacDonald), the transfer to permanent buildings was practically complete. During World War II the work of the Station was diverted to serve military needs; thus for the development of telephone systems, testing in the presence of very high levels of ambient noise, such as are reached in tanks and aircraft, became a common practice. The stage has now been reached when considerable changes are being made in the arrangement of staff and work carried out in the various buildings.

The present layout of buildings on the site is shown in Figure 1. The pond, on the left of the main Research Building, is a natural feature which has been retained for its ornamental value. The buildings for the radio laboratories lie to the left of the pond, except for one which is now being taken over for general research purposes. Some of the buildings toward the back of the site are used by the Training School, where the engineering employees from all parts of the country attend courses in Post Office engineering practice. The School, which was once a part of the Research Branch, has now been organized as a separate Branch, and will, when sufficient accommodation becomes available, be moved elsewhere and so permit a first step in the expansion of the research laboratories. An additional site area of some two and a half acres, adjoining the porter's lodge, has recently been acquired where buildings for future expansion will be erected. The small blocks marked A to N at the top on Figure 1 are air-raid shelters built under the School's external construction practice ground.

A view of the main research building is shown in the photograph on the first page of this article. On each of the three stories, the rooms occupying the two wings of the buildings are large laboratories; an interior view of one, concerned with central-office switching systems, is shown in Figure 2. The rooms on either side of the corridor between the wings are mostly offices and small laboratories, some of which were specially built for particular purposes—for example, the pair of rooms shown in Figure 3 are used for voice-ear testing of telephone systems, the inner room, seen through the double doors, is soundproof and both are treated for sound absorption.

The Research Branch is responsible for the maintenance of the Engineering Department's main library, which covers technical and other literature on all phases of science and engineering related to Post Office activities. The reading room is on the second floor above the main entrance door. A part of this room is shown in Figure 4.

About 560 people are now employed in the Research Branch. Brief classification of the personnel is difficult; about forty officially recognized grades of employment, common to the Engineering Department as a whole, are represented, but this number is inadequate to describe the variety of activities at the Research Station. There are, for example, no special grades for mathematicians or for librarians; also a "workman" may be a workshop craftsman, or a storekeeper, or a young laboratory assistant—perhaps in process of taking a university degree. Broadly speaking, however, it is estimated that some 300 are directly engaged on experimental work, including most of the more highly paid grades, 120 are workshop staff, including draughtsmen, and 45 have clerical duties.

Recruitment generally is by methods common to the Department, i.e., by direct recruitment of men to a low-level grade or by competition to a higher grade. The Research Branch, however, receives a relatively high percentage of the university graduate recruits to the Department, and its intake at the lowest level, youth-in-training, is selected from youths with relatively high educational achievements. Openings occur from time to time for staff exchange to or from other Branches or Regions, or even other Departments, by transfer or on promotion. It is now planned to widen the normal scope of recruitment by the addition of scientists at grades common, not only to the Engineering Department, but to other Government laboratories, to which such officers can, in the course of their careers, have outlets.

Close liaison with the other headquarters

Fig. 3—Pair of rooms used for voice-ear testing of telephone systems

Branches more directly concerned with maintenance and development of engineering plant is, of course, essential. Some of the work of the Research Branch comes from direct requests made by these Branches, either arising from difficulties experienced with existing equipment or in anticipation of new requirements. When an investigation is needed, a case number is allotted, which serves as a means of controlling and coördinating the work, whether it involves a single specialist research worker only or several groups dealing with such diverse aspects as, for example, lines transmission equipment, chemistry and contact phenomena. In any case the work is concluded by the writing of a report; if the subject matter is sufficiently interesting, copies of the report are sent, not only to Branches of the Engineering Department, but also to British Government research establishments and other organizations. Wider publication is given to work which is thought to have wider interest by means of contributions by the officers concerned to technical journals, notably the *Journal of the Institution of Electrical Engineers* and the *Post Office Electrical Engineer's Journal.*

Many cases are originated by the Research Branch to cover, for example, work which is a by-product of an investigation but worthy of separate record, such as the development of a new form of measuring technique or equipment, or work of a more fundamental nature, aiming to fill some deficiency of useful knowledge without reference to any specific requirement or application. There are, in fact, two broad classes of questions to which the Research Station seeks to find answers. One class is represented by questions relating to immediate or foreseeable needs for new developments or improvements. The other is a modest attempt at exploration of the unknown with a view to testing any findings for useful application. The aim is therefore to deal with the former class as efficiently as possible while retaining some margin of staff which can be left undisturbed to concentrate on the latter. This task is especially difficult just now, due to the accumulated arrears of normal development from the war years and to the present shortage of manpower and accommodation.

Fig. 4—Part of the reading room in the main library

Recent work at Dollis Hill includes:

The development, maintenance and improvement of standards for frequency and acoustic measurements of high accuracy, and of telephone transmission.

The design and installation of terminal and repeater equipments for coaxial cable transmission systems.

Research and development leading to the submerged repeaters for the Holyhead—Isle of Man and Anglo-German cables.

The design and construction of the talking clock which gives announcements of time on request, accurate within one-tenth of a second, at ten-second intervals.

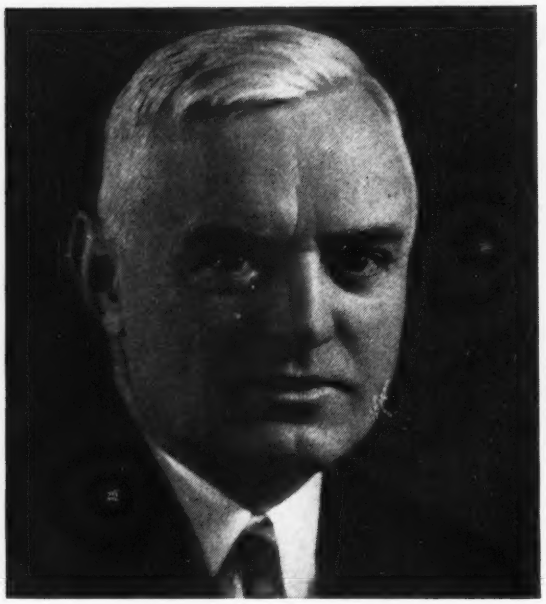
The design of equipment for extending the telephone network to neighboring islands by very high-frequency radio links.

The design of a system and apparatus for sending signaling impulses by voice-frequency tones on trunk networks.

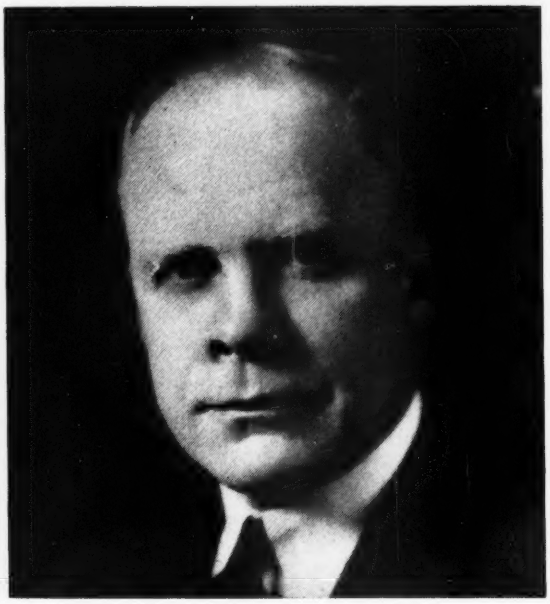
The design of a hearing-aid; this work was undertaken on behalf of the Medical Research Council.

The design and construction of the multiple-unit steerable-antenna radio-receivers at Cooling Marches radio station.

The development of methods and apparatus for restoring equipment *in situ*, in premises damaged by enemy action.



William F. Hosford



Stanley Bracken

William F. Hosford, Vice-President in Charge of Operations and a director of the Western Electric Company, retired on May 30. Stanley Bracken, Vice-President in Charge of Manufacture, has been elected Executive Vice-President. Mr. Bracken succeeds Mr. Hosford on the Board of Directors of Bell Telephone Laboratories. H. C. Beal, engineer of manufacture, has been elected a director and vice-president to succeed Mr. Bracken. F. J. Feely, who continues as manager of Western Electric's Buffalo shops and electronic shops, becomes engineer of manufacture in addition to his other duties.

Honorary Degree to R. A. Heising

At the recent commencement ceremonies of the University of North Dakota, R. A. Heising was awarded the honorary degree of Doctor of Science. The citation accompanying the award described his many accomplishments with the Laboratories. His important inventions in vacuum-tube technique, in oscillators, modulators, amplifiers and in carrier current and radio transmission systems are covered by 122 patents. Of particular interest are his patents pertaining to multiplex carrier line systems; constant current modulation, multiplex radio transmission with plurality of different intermediate frequency carrier waves and the class C amplifier which, on account of its high efficiency, has been so extensively used in high-powered stations.

Mr. Heising's contributions to the radio art are widely recognized and utilized throughout the world, and have been essential to the rapid expansion and commercial utilization of that art in all its forms, whether between fixed or mobile stations, and whether for individual communication or broadcasting.

A.I.E.E. Prizes for Best Papers

J. A. Becker, C. B. Green, and G. L. Pearson have been awarded the 1946 A.I.E.E. National Prize for the best paper in the Field of Theory and Research. The title of the paper was *Properties and Uses of Thermistors—Thermalloy Sensitive Resistors*. A. G. Ganz received Honorable Mention for his paper *Applications of Thin Permalloy Tape in Wide Band Telephone and Pulse Transformers* in connection with the award for best paper in the Field of Engineering Practice presented in 1946. The awards were made at the Summer General Meeting of the Institute, held in Montreal during the week of June 9.

A.S.E.E. Meet at Murray Hill

Approximately 340 members and guests of the Middle Atlantic Section of the American Society for Engineering Education (formerly known as the Society for the Promotion of Engineering Education) gathered for its Spring Meeting at the Murray Hill Laboratories on May 24. Registration was followed by an Open House period, during which

members of the Society and their guests visited a number of research and development laboratories.

G. B. Thomas opened the meeting by introducing O. E. Buckley, who gave a welcoming address. The major portion of the morning session was devoted to a symposium on *Work of Technical Graduates in the Bell Telephone System*. The subject was opened with a paper prepared by D. S. Bridgman of the A T & T, presented in his absence by R. K. Honaman. Other papers were presented by R. A. Deller, O. Carpenter (Western Electric) and S. E. Stromberg (New York Tel.). At the afternoon session, presided over by Professor C. Higbie Young of Cooper Union, Chairman of the Middle Atlantic Section, the subject was *Ways and Means of Implementing the Report of the Hammond Committee on Engineering Education After the War*. Ralph Bown was one of the speakers at this session.

A special program arranged for the women guests included a trip through Jockey Hollow, luncheon at the Old Mill Inn, Bernardsville, and a visit in the afternoon to the Morristown National Historical Park Museum. The women and men gathered again in the late afternoon for a social hour, followed by dinner in the Murray Hill restaurant. Activities were concluded with a one-hour *Engineering Demonstration* at which R. L. Jones presided. In this program W. C. Jones gave illustrations of the manner in which electrical network theory is applied to the acoustical development of telephone instruments; E. I. Green described new systems developments and demonstrated some of the properties of microwaves; and A. R. Soffel gave a brief talk introducing the playing of two recordings over the stereophonic system.

The Laboratories members of the committee in charge of general arrangements for the meeting were R. K. Honaman, G. B. Thomas, R. A. Deller and L. S. O'Roark.

Veterans' Insurance

National Service Life Insurance means undeniable values in security and protection for the veteran. This insurance includes:

1. Unrestricted choice of beneficiaries.
2. Lump sum settlement or choice of three monthly installment options.
3. Three endowment plans payable to you at maturity, making six permanent plans in all.
4. Total disability income benefits for an additional premium.
5. Right to purchase insurance after discharge under certain conditions.
6. Low premium rates because the Government pays all operating expenses.
7. No restrictions as to residence, travel, occupation or military or naval service.
8. Reinstatement of insurance upon pay-

July Service Anniversaries of Members of the Laboratories

45 years

W. C. F. Farnell
F. F. Lucas

40 years

W. E. Mougey

35 years

A. A. Catlin
A. W. Hayes
W. A. Rhodes
E. L. Rudd
H. F. Stover

30 years

S. W. Allison
H. D. Bender
D. E. Branson
C. E. Cerveny
R. H. Clapp
G. H. Duhnkrack
G. F. Heuerman
J. B. Irwin
Harry Nyquist
A. L. Petizon

25 years

R. C. Avery
D. P. Barry
F. B. Blake
L. G. Bostwick
R. G. Bowen
Mildred Brosnan
F. W. Brunnengraber
H. T. Budenbom
V. T. Callahan
J. E. Cassidy
L. J. Cobb
Florence Conley
Ada Corcoran
F. J. Daniels
A. E. Dietz
H. T. Douglass
J. M. Duguid
L. A. Elmer
W. J. Farmer
P. B. Flanders
George Garbacz
D. M. Hannum
R. A. Hecht
R. E. Hersey
Frank Huebsch
D. F. Johnston
R. A. LeConte
A. F. Leyden
J. A. Mahoney
Kathryn McGaughin
John Meszar
Joseph Nedelka
T. H. Neely
N. D. Newby
R. J. Nossaman
R. S. Ohl
G. N. Queen
W. K. St. Clair
H. W. Salch
H. A. Sheppard
Adelaide Sweeney
W. W. Werring
I. W. Whiteside

20 years

Martha Bohme
W. J. Bruder
Walter Endersen
C. E. Fay
John Gris
I. L. Hopkins
E. P. Hullah
P. V. Koos
W. A. MacMaster
S. T. Meyers
F. A. Minks
O. J. Murphy
E. G. O'Donovan
F. W. Peters
E. J. Quinn
George Seidel
W. C. Slauson
L. R. Smith
O. L. Walter
Elsie Weyell
E. S. Willis

15 years

E. A. Galambos
K. A. Williams

10 years

Wilfred Bauer
H. A. Baxter
G. A. Beck
U. S. Berger
D. W. Boddy
Kenneth Bullington
B. J. Cregan
A. H. Diegler
P. V. Dimock
K. S. Dunlap
R. D. Ehrbar
R. R. Gay
W. B. Graupner
N. I. Hall
R. A. Kempf
Joseph Kocan
W. E. Lichte
H. J. McSkimin
O. J. Morzenti
F. A. Parsons
G. W. A. Pentico
M. X. Richardson
A. E. Ritchie
F. N. Rolf
L. G. Schimpf
K. E. Schukraft
Helen Seastrom
J. A. Seifert
J. P. Slickers
W. H. Thatcher
R. H. Van Horn
T. J. West
L. F. Willey
R. C. Winans

Dorothy Cose has recently been given a special assignment at Holmdel as a member of the Research Staff Department. Mrs. Cose was known to many at West Street when she was Dorothy Gugel, A. F. Gilson's secretary

ment of one monthly premium on arrears and additional premium for current month.

The Veterans' Administration is conducting a campaign urging all veterans of World War II to reinstate National Service Life Insurance, if they have allowed it to lapse. Reinstatement privileges are very liberal and *a medical examination will not be necessary until August* 1, 1947; after that date, an examination will be required.

Call at your local office, Veterans' Administration, or Extension 109 or 898 at West Street, or 226 at Murray Hill.

South African Baedeker

W. E. Campbell returned on May 22 from a visit to his former home in the Union of South Africa. While there he delivered a series of seven lectures on corrosion and lubrication at his alma mater, the University of the Witwatustand, to the advanced students and to local technical men.

His headquarters were in Johannesburg, the gold mining center, but he made a visit by air to Capetown, Port Elizabeth and Durban. He also visited the Kruger National Park, a vast game reserve.

He found that the country had undergone tremendous development during his twenty-one years of absence, and is just beginning to develop a chemical industry. He was astonished at the modernity and efficiency of the transportation and traffic control systems and found that most of the amenities of American living were readily available. The telephone system in the cities was a step-by-step dial system, but was far below ours in quality of service.

He took a large number of color pictures during the trip, which was made via airplane in just under three days each way, routed through Lisbon, Portugal, and down the African west coast.

Changes in Organization

T. C. Fry, Director of Switching Research, has been appointed Director of Switching Research and Engineering, assuming in addition to his present duties the direction of the work of the Switching Engineering groups, except Telegraph, formerly under H. M. Bascom, who retired on June 30. E. F. Watson, Telegraph Engineer, and the group reporting to him, now report to G. W. Gilman, Director of Transmission Engineering.

With the retirement on June 30 of C. W. Green, Military Relations Personnel Officer and member of the Labor Relations Committee, R. G. McCurdy became a member of the Labor Relations Committee, which now consists of Mr. McCurdy, H. C. Atkinson and D. W. Eitner. Mr. Green's duties as Military Relations Personnel Officer have been transferred to the Personnel Department. E. D. Johnson and Mrs. Hilda Newton are now members of the organization reporting to Morton Sultzer.

R. C. Davis has been made Switching Development Engineer, replacing E. J. Kane, who transferred to the Western Electric Company as reported in the last issue of the Record. F. A. Korn replaces Mr. Davis, and N. I. Hall temporarily takes charge of the development project that was formerly handled by Mr. Korn.

Mobile Telephone Service as an Aid to Navigation

Delegates from twenty-six foreign countries, attending the recent International Meeting on Marine Radio Aids to Navigation at New London, Conn., were given an opportunity to try out Bell System mobile telephone service aboard the Coast Guard cutter *Campbell* and the Maritime Commission training ship the U.S.S. *American Sailor*.

The equipment, installed on these ships by

the New York Telephone Company, was of the Western Electric Type 239 variety and identical with that used in vehicles for mobile telephone service on the "highway" frequencies (30-44 megacycle range).

Through the coöperation of The Southern New England Telephone Company, delegates cruising off New London made calls to land telephones via the New London land station of the New York-Boston "highway" system, which is now undergoing extensive tests prior to regular commercial operation. Calls were also made between the two ships.

H. B. Coxhead, D. K. Martin and C. A. Chase attended the meetings. R. V. Crawford supervised the installation of the equipment on the *Campbell* and *American Sailor* and went to New London on the latter.

News Notes

A. B. Clark spoke on *Communications Trends* before the combined faculties and students of the Air War College and the Air Command and Staff School at Maxwell Field, Ala., on May 16. Later he repeated the talk before the faculty and students of the Communications Division of the AAF Special Staff School at nearby Gunter Field.

M. H. Cook and E. L. Nelson attended the annual inspection on May 28 at Langley Field. With H. B. Fischer and R. H. Ricker they participated in a quality survey conference from May 5 to 7 at Burlington on Bell System mobile radio equipment. Mr. Nelson, Mr. Fischer and R. C. Newhouse witnessed the Coast Guard demonstration of radio aids to navigation on the S.S. *American Sailor* on May 12 during a trip from the North River to Ambrose Lightship. Mr. Newhouse also attended a session on the International Meeting of Marine Aids to Navigation in New York.

J. E. Corbin, aboard the steamer *J. T. Hutchinson* on a trip from Two Harbors, Minn., to Detroit, observed the operation of experimental radar on trial on that vessel.

J. B. Combs and R. E. Carpenter inspected recent Sonar installation on the U.S.S. *Wilke* and supervised the initial tests on the equipment at the Brooklyn Navy Yard.

R. H. Ricker and W. C. Babcock discussed mobile antenna design for Bell System vehicular use at the H. H. Buggie Company, Toledo. Mr. Ricker visited Winston-Salem for discussions of manufacturing problems related to mobile equipment.

W. H. C. Higgins attended a conference on magnetic amplifiers at the Bureau of Ordnance in Washington.

J. B. Bishop gave a lecture on *Transmitters* on May 8 before a joint session of the New York Section of I.R.E. and the Communication Division of the A.I.E.E. as a part of a series on FM. He also spoke on *Western Electric FM Broadcast Transmitters* before the Dallas section of the I.R.E.

S. C. Hight attended conferences that were held at the Bureau of Ordnance, Washington, on May 12 and 13; and R. A. Devereaux on May 20 and 21.

F. C. Ong visited Burlington to discuss the 1-kw FM transmitter.

H. T. Budenbom visited the Bureau of Ships, Washington, in connection with a meeting of the Army-Navy R. F. Cable Coördinating Committee, and the Naval Research Laboratory at Anacostia. Mr. Budenbom attended a meeting of the RMA Waveguide Committee in New York. With J. P. F. Martin, he participated in a conference on high-power transmitter components with Navy officials at the Bureau of Ships, Washington.

Charles Seacord, left, and Thomas Smith, right, put a finishing coat on cases which will hold equipment to be used for dust studies in telephone exchanges

Papers presented by Laboratories members at the A.I.E.E. summer general meeting on June 9 to 13 in Montreal were *Pulse Code Modulation* by H. S. Black and J. O. Edson; *An Electronic Regenerative Repeater for Teletypewriter Signals* by R. B. Hearn; and *Engineering Applications of Relay Type Computers* by H. W. Bode and E. G. Andrews.

S. O. Ekstrand went to Emporium, Pa., to visit the Sylvania Products Company for a meeting on receiving tubes. With C. E. Snow of Western Electric, he visited the Aeronautical Radio Corporation, Washington, to discuss vacuum-tube problems in airline communications.

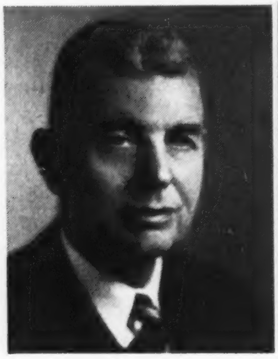
Retirements

Recent retirements from the Laboratories include H. M. Bascom and U. S. Ford, with 41 years of service; G. P. Tromp, 37 years; W. A. Southwick, 34 years; Cornelia Miller, 29 years; C. W. Green, 28 years; and Rafael Fontrodona, 23 years.

Charles W. Green

Mr. Green, Assistant to the Executive Vice-President and Military Relations Personnel Office, was graduated from the University of Wisconsin in 1907 with a B.S. degree. He joined the faculty of the Massachusetts Institute of Technology as an instructor, becoming an Assistant Professor in 1914. During World War I he was first a captain and then a major in the U. S. Army.

Following the war, Mr. Green entered the Engineering Department of the Western Electric Company. After a short period in the Physical Laboratory, he transferred to the power group of the Systems Development Department. In the summer of 1920 he was placed in charge of transmission circuit development for voice-frequency telephone repeaters. Two years later, circuit development for carrier telephone systems was placed under his supervision. From then until 1939 his responsibilities covered transmission circuits for toll telephone communications, including, in addition to the above, terminal and control circuits for radio links, transmission measuring circuits for toll maintenance, and terminal circuits for the coaxial system. He was intimately associated with the development of the type-C three-channel and the type-J twelve-channel open-wire carrier systems and with the type-K twelve-channel carrier on cable. The fundamental invention of the feedback amplifier by H. S. Black came from Mr. Green's organization. The use of feedback to reduce internal distortion has made practical the transmission of twelve, and later many more, channels through the single repeaters used in the multi-channel systems.



C. W. Green

H. M. Bascom

Early in 1939 Mr. Green went to London as Technical Representative in Europe of the American Telephone and Telegraph Company and Bell Telephone Laboratories. When the London office was closed soon after the beginning of World War II, Mr. Green returned to the A T & T and in April, 1940, came back to the Laboratories as a Research Consultant. He later became Military Relations Personnel Officer and since October, 1944, he has also been Assistant to the Executive Vice-President.

Henry M. Bascom

Mr. Bascom's communication experience dates from November 2, 1899, when he joined the Acme Telephone Company in New York City. He worked for a year in this company and then for a period of six years in the Ericsson Telephone Company, which was also located in New York.

In 1906 he entered the Engineering Department of the New York and New Jersey Telephone Company in its Brooklyn office, and in 1909 transferred to the Engineering Department of the A T & T, where he soon became an expert on equipment for manual central offices.

With the formation of the D & R in 1919, Mr. Bascom became Local Central Office Development Engineer responsible for all local central-office apparatus and equipment, manual and dial, and for PBX switching. When this department was merged with the Laboratories in 1934, he continued these responsibilities, with the title Local Facilities Director of the Systems Development Department. For several months in 1938 he was in Europe studying technical developments there. In 1940 Mr. Bascom became Director of Switching Engineering, at the same time taking over the telegraph development group. This group undertook the development of world-wide teletype radio communication systems and the development of the Mark XX radar during World War II.

Mr. Bascom was responsible for the development of composite signaling circuits which automatically compensated for variations in earth potentials.

About seventy patents are evidence of Mr. Bascom's specific contribution to telephony. It is significant that, in many of these, he is joined with others whose thinking he had stimulated.

At the outset of the machine switching program he became intimately connected with its development. His judgment entered into the

many important decisions made during the stages of initial development, trial installation and final refinements of the panel system. He was also engaged in the development of the crossbar system, being responsible for establishing the operating requirements that are involved. Yet his keen power of analysis and his success in devising apparatus and methods of operation have contributed greatly to the manual system. Recognizing certain economic limitations in available common-battery switchboards for small central offices, he initiated in 1931 the development of a low-capacity and low-cost manual board now known as the No. 12 switchboard.

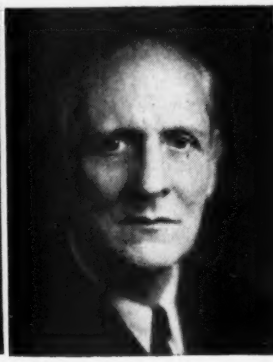
Through his wide personal acquaintance in the Associated Companies he has a very broad and comprehensive understanding of the needs of those companies and has an unusual ability to translate these needs into definite requirements so set up that apparatus and equipment can be designed. In addition, he has the faculty of applying advances in related arts to improvement of the apparatus and equipment used in the telephone plant.

William A. Southwick

Mr. Southwick was graduated from the University of Maine in 1912 with the degree of B.S. in E.E. and immediately joined the student course of the Western Electric Company at Hawthorne. After completion of this course, he transferred to the Hawthorne division of the Apparatus Development Department that was engaged in the development of quadded cable. Mr. Southwick's early work was directed toward improvement of the transmission qualities of this type of cable, which involved studies of the effect of variations in methods of insulating, cotton binding, twisting, stranding and drying. He remained at Hawthorne until 1928, when he transferred to the Kearny division of the Outside Plant Development Department, where he played an important part in the development of protective coverings for buried cables. In 1930 he went to the Point Breeze plant, where he has since been concerned in the development of modern toll cables, designed for carrier operation.


W. A. Southwick


U. S. Ford


Rafael Fontrodona


G. P. Tromp


Cornelia Miller

Ulysses S. Ford

After completing an engineering course at Pratt Institute in 1906, Mr. Ford joined the old New York and New Jersey Telephone Company and engaged in traffic and equipment engineering. Two years later he transferred to the Western Electric Company and traveled around the country on field inspection and tests of central-office equipment. During World War I he had charge of the installation of telephones and PBX systems in various military camps.

Since 1919, Mr. Ford has been a member of the Equipment Development Department, where he was concerned with the development of manual switchboards and the development of power circuits for the Key West-Havana carrier cable. He was transferred to the trial installation group in 1941, and during World War II worked on preproduction equipment for the Armed Forces, mainly on the eight-channel microwave system. Since the war, Mr. Ford has been concerned with the rural power-line carrier-telephone trials and with video television amplifiers.

Rafael Fontrodona

Mr. Fontrodona has been associated with the Building Service Department since 1924 when he joined the Laboratories as a night cleaner. Since then he has spent all of his time with the Laboratories on various assignments in the above department. Ralph, as he was better known, will be missed by his many friends, especially those who used to converse with him in Spanish.

Gerard P. Tromp

From his native country, The Netherlands, Mr. Tromp went to Bingen, Germany, for further study, and received a degree in electrical and mechanical engineering there. Shortly afterwards he came to this country and joined the Engineering Department of the Western Electric Company. He was briefly associated with the Apparatus Inspection Department, checking the shop inspection of plugs, desk stands. Later he joined what is now the Switching Apparatus Development Department and specialized in manual apparatus design analysis. He was exceptionally adept at this work, which, together with his long experience, made him invaluable in the investigation of new designs and trouble conditions arising on apparatus in manufacture and in service.

He has made many contributions to telephone apparatus which has insured its successful operation in service. Among the most important are the shepherd crook spring used in all universal lever type keys and the spring arrangement of the switch hook in the present designs of combined handset mountings.

Mrs. Cornelia Miller

After a year in a private business school, Mrs. Miller joined the Patent Department. She was a stenographer for two years and the chief stenographer for a similar period. Since then, she has been secretary to E. V. Griggs, Assistant General Patent Attorney. For a number of years Mrs. Miller was pianist of the Bell Laboratories Club's Symphonic Orchestra and of the Dance Orchestra.

News Notes

L. F. Moose attended a session of the American Physical Society in Washington. He also visited the Bureau of Ships to discuss the operation of vacuum tubes and Navy radar equipments. With members of the Airborne Instrument Laboratory in Mineola, he discussed the application of special vacuum tubes.

G. N. Vacca and C. V. Lundberg attended a conference at Point Breeze on telephone cords. F. S. Malm and Mr. Vacca discussed rubber-covered wire problems with Western Electric engineers at Point Breeze.

Prize Winners in Photographic Print and Slide Exhibition

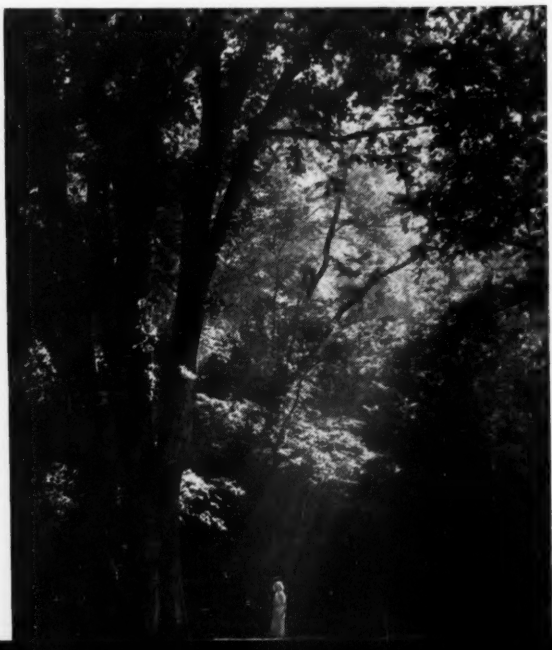
The twenty-first annual photographic print and slide exhibition was held in the auditorium at West Street during the week of June 16. First, second and third prize winners (listed in that order below) were: *Landscapes and Marines,* R. A. Buckles, Jr., L. E. Cheesman and L. Ehrmann; *Portraits,* N. C. Norman, W. J. Rutter and J. F. Neill; *Child Studies,* E. von Nostitz, L. E. Cheesman and W. A. Depp; and *Miscellaneous,* W. S. Suydam, R. A. Buckles, Jr., and J. F. Neill. A total of 108 prints were submitted and the judges were Harvey Falk, Martin Polk and David Teich, noted photographic pictorialists of New York City.

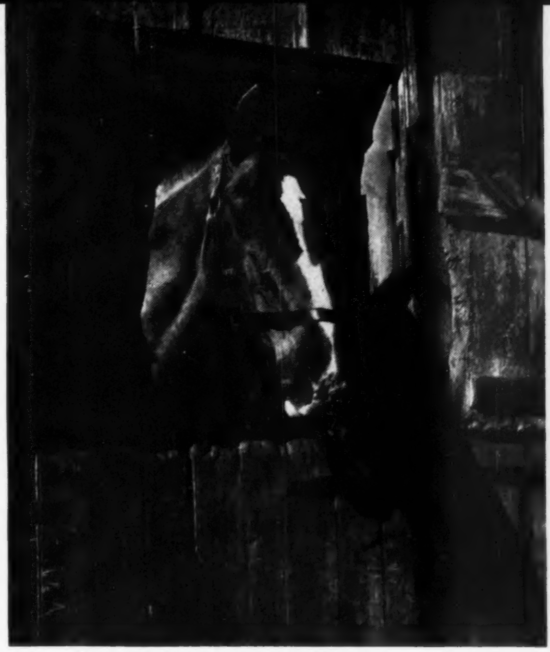
The five winners in the color slide contest were J. R. Davey, P. B. Findley, F. K. Harvey, W. J. Rutter and K. M. Weeks. The 172 slides submitted were judged by O. K. Taylor, L. H. Wadsworth and P. R. DuBois of the New York Color Slide Club.

Members of the Laboratories Camera Club responsible for the success of the Salon include E. K. Alenius, C. T. Boyles, W. S. Suydam and E. von Nostitz.

Portraits—N. C. Norman

Landscapes—R. A. Buckles, Jr.





Miscellaneous—W. S. Suydam

Child Studies—E. von Nostitz

MEMBERS of Electronic Apparatus Development who have visited Allentown, their new work location, either on a conducted tour or a personal visit are: J. H. BEINER, J. E. CLARK, S. O. EKSTRAND, G. B. GUCKER, C. MAGGS, L. F. MOOSE, E. J. MOSKAL, V. L. RONCI, E. G. SHOWER, R. L. VANCE, W. VAN HASTE, J. W. WEST, R. C. WINANS, W. H. WOBIG and W. O. ZVONIK. The move to the new location is expected after the first of September.

J. R. WILSON and N. Y. PRIESSMAN discussed varistors on May 28 at the General Electric plant in West Lynn, Mass. Mr. Wilson, V. L. RONCI and S. O. EKSTRAND went to the Schenectady General Electric plant for conferences on vacuum tubes. Mr. Priessman attended the A.I.E.E. convention in Montreal.

A. B. HAINES and E. A. POTTER visited the American Transformer Company in connection with the procurement of transformers.

W. A. MUNSON attended a conference of the Psycho-Physiological Planning of the Office of Naval Research in Washington.

E. C. WENTE attended meetings on May 8 to 10 of the Acoustical Society of America in New York. On May 9, F. M. WIENER was elected a Fellow in the Society. During the meetings, papers were presented by W. A. MUNSON on *The Growth of Auditory Sensation;* M. B. GARDNER on *A Pulse-Tone Technic for Audiometric Threshhold Measurements;* D. M. CHAPIN on *Measurement and Calculation of Under-Signal Noise in Magnetic Recording;* G. W. WILLARD on *The Radiation of an Ultrasonic Focusing Radiator;* and by W. P. MASON and H. J. MCSKIMIN on *Attenuation and Scattering of High Frequency Sound Waves in Metals and Glasses.*

S. O. MORGAN has been appointed to the Board of Visitors for Union College. This Board will review the curriculum and facilities of the college and will make recommendations to the Board of Trustees. Mr. Morgan's assignment is the Chemistry Department.

R. M. BURNS went to Point Breeze for discussions of rubber developments.

A. R. KEMP and M. L. SELKER attended the American Chemical Society, Rubber Division, meeting in Cleveland at which a paper on *Sulphur Linkage in Vulcanized Rubber,* of which they are authors, was presented.

G. H. BAKER and F. H. WILLIS attended the joint meeting on May 5 to 7 of the American Section of the I.R.E. and the International Scientific Radio Union in Washington.

V. T. WALLDER was at Hawthorne and Buffalo for conferences on thermoplastic wire and cable problems.

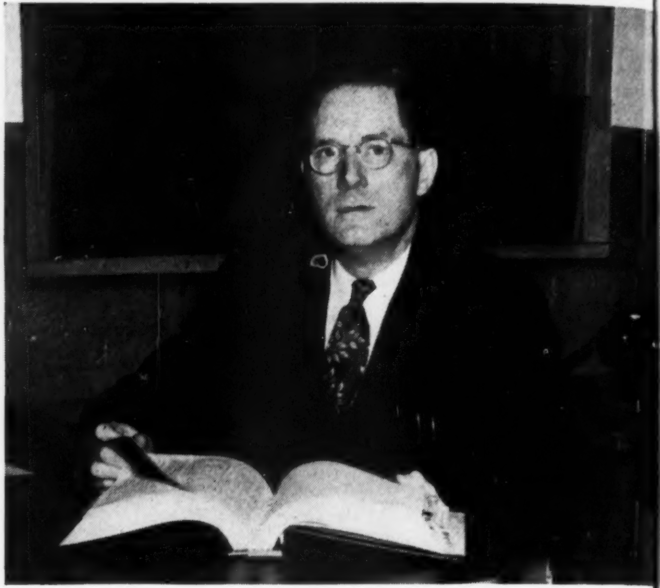
J. B. HOWARD discussed outdoor exposure plot plans for wire and cable coverings.

G. K. TEAL and H. G. WEHE attended the May 1 to 3 meetings of the American Physical Society in Washington.

K. G. COUTLEE attended a special meeting in Philadelphia of the Subcommittee XII of the A.S.T.M. Committee D-9 to discuss revision of insulation resistance test methods.

C. J. FROSCH and W. ORVIS discussed plastic problems at Providence.

W. SHOCKLEY and R. M. BOZORTH attended a meeting in Chicago of the Institute for the Study of Metals at which Mr. Bozorth presented a paper on *Ferromagnetic Resonance at Microwave Frequencies.*



J. P. Greene and his daughter Marian are both members of the General Service Department. Mr. Greene is responsible for a laboratory and order service group at West Street and another in the Davis building. Marian does the clerical work in connection with all photographs, photostats, blueprints and tracing reproductions

K. G. Compton and J. Leutritz, Jr., attended the annual convention of the American Wood Preservers Association, April 21 to 25, at Portland, Oregon.

B. W. Kendall was elected a vice-president of the New York Electrical Society at its annual meeting in Garden City, N. Y.

R. A. Sykes assisted in the production of a motion picture on *Quartz Crystals,* which is being made in Chicago for the Western Electric Company.

C. A. Webber and W. J. King attended a meeting of the Army-Navy Radio Frequency Cable Coördinating Committee at the Bureau of Ships, Washington.

E. B. Wood, C. A. Webber and H. H. Staebner were at Point Breeze for a discussion of cords for the new combined telephone set.

D. R. Brobst conferred at Hawthorne regarding switchboard cable covers and enameled wire. He also discussed lacquered wire with engineers at Buffalo, N. Y.

O. C. Eliason was in Chicago in connection with studies of air conditioning.

C. B. Green spoke on *Thermistors* before the Boston Section of the I.R.E. at Cambridge and before the Twin Cities Section of the Instrument Society of America at Minneapolis.

W. J. King's recent trip to the General Electric Company at Pittsfield, Mass., was in connection with high-voltage cables and connectors.

W. O. Baker spoke before the Polymer Group at the National Bureau of Standards on *Polar Coördination in Polymers.*

W. W. Brown visited the U. S. Rubber plant at Mishawaka, Indiana, and the Western Electric Company at Hawthorne in connection with telephone operators' chairs.

S. C. Del Vecchio, at the Ballistics Research Laboratory of the Aberdeen Proving Grounds, supervised the start of installation of the Complex Computer built for the Government by the Laboratories.

F. W. Treptow visited the Forest Product Laboratories at Madison, Wisconsin, on plywood studies.

H. J. Berka discussed fluorescent lighting problems with the Southern Bell Telephone and Telegraph Company in Atlanta.

S. H. Willard, C. H. Achenbach, G. H. Downes and H. J. Berka attended a lighting conference for Bell System engineers at the General Electric Lighting Institute, Nela Park.

D. E. Trucksess attended a Quality Survey at the Power Equipment Company, Detroit.

M. O. Fichter was at RCA in Camden on television monitoring problems.

C. A. Smith discussed microwave radio systems at Winston-Salem.

F. A. Minks attended the Signal Corps Association conference at Fort Monmouth.

T. H. Chegwidden and J. A. Ashworth, at a conference in Washington, discussed magnetic devices with Navy representatives.

A. B. Haines and B. E. Stevens were in Alpha, N. J., in reference to transformers and coils for amplifier use. Mr. Haines and D. W. Grant attended conferences at Burlington and Winston-Salem on sound amplifiers.

S. King inspected the highway mobile radio telephone system at New Haven.

O. B. Jacobs, N. C. Youngstrom, D. E. Thomas and J. J. Gilbert were in Cambridge, Mass., at the Simplex Wire and Cable Company plant.

A. H. Hearn is studying the relation between seasoning processes and the occurrence of internal decay in southern pine poles at the southern treating plants.

P. S. Darnell visited ANEESA at Red Bank to discuss preparation of Government specifications on radio frequency inductors.

A symposium on the subject of *Testing Techniques and Facilities for High-Frequency Wire Transmission Systems* was presented by members of Bell Laboratories to representatives of the A T & T, Signal Corps representatives, and others. The symposium comprised a series of talks, together with demonstrations of equipment as follows: *Systems Testing Problems* by E. I. Green; *Laboratory Measurements* by J. G. Ferguson; *Portable and Mobile Equipment for L-1 Coaxial* by J. T. O'Leary; *Other Test Equipment for L-1 Coaxial* by L. G. Abraham; *Television Test Equipment* by H. J. Fisher; *Impedance Testing Apparatus* by S. J. Zammataro; and *Transmission Testing Apparatus and Frequency Standard* by E. P. Felch.

OBITUARIES

F. T. Forster
1883-1947

W. O. Braatz
1904-1947

A. A. Burri
1894-1947

Frank T. Forster, May 11

Mr. Forster was graduated from Union College in 1905 with a B.E. degree in Electrical Engineering. He had been associated with Dr. Steinmetz at the General Electric Company before becoming a member of the Technical Staff at the Laboratories in 1923. During his twenty-four years of Bell System service, he had been engaged in the development of storage batteries and related apparatus. When the war came, he worked on Government projects, including tests of storage cells for aircraft and Bell System problems arising from the need for substitutes for critical war materials used in telephone batteries. He has also been concerned with the development of explosion-proof devices for storage batteries.

A philatelist and member of the Laboratories Stamp Club, Mr. Forster specialized primarily in South American and Canadian stamps. He also belonged to the photographic club and to the bowling league at West Street. His wife and two sons survive.

William O. Braatz, May 22

Mr. Braatz, a member of the Laboratories Staff, joined the Purchasing Department as a clerk in 1929, the year in which he was graduated from New York University. He became a supervisor in charge of the "small order" group and then a buyer responsible for building materials and hardware. More recently he had been concerned with the procurement of office supplies for the Laboratories. Mr. Braatz, before his illness, was active in the Bell Laboratories Bridge Club and had served as its chairman. He is survived by his wife and two children of high school age.

Alfred A. Burri, June 2

Mr. Burri was an Instrument Maker in the Development Shops Department, with service since June 4, 1944. His work for the most part was on waveguide details and assemblies in the shop at the Graybar-Varick building. Before coming to the Laboratories he had been in business for himself.

Engagements

*Jacqueline Lewis–Henry Richardson
*Mariane Luckey–Victor Franklin
*Lois Wadsworth–*William Bengraff

Weddings

*Elizabeth Armstrong–*I. E. Wood
*Muriel Cadmus–Francis L. Kossuth
Eleanor Cope–*Edward J. Speck
*Ruth Dessart–Leo Scodellero
*Amelia Flaim–Harold Molloy
Marjorie Johnson–*R. M. Moody
*Elizabeth McIlravey–*Albert B. Watrous
Doris Messmer–*Harry G. Reimels
*Doris Middleton–Raymond Hitchen
*Janet Pape–F. L. Dignon
*Rose Sena–C. M. Chiusano
*Jean Smullen–Gerard A. Cannon
*Genevieve Sokolosky–John Harrington
*Carol Vreeland–*Kermit A. Williams
*Jeannette Warnetzka–C. G. Renz

*Members of the Laboratories. Notices of engagements and weddings should be given to Mrs. Helen McLoughlin, Room 803C, 14th St., Extension 296.

"The Telephone Hour"

NBC, Monday Nights, 9:00 p.m.

July 7	*Nelson Eddy*
July 14	*Polyna Stoska*
July 21	*Basil Rathbone*
July 28	(*to be announced*)
Aug. 4	*Ezio Pinza*

E. C. Blessing and A. C. Velie obtained field test data at Springfield, Mass., from May 19 to 23 on K-2 carrier repeaters.

H. C. Fleming, at the Albany carrier repeater office, witnessed the trial of an improved power output tube for K-2 repeaters.

A number of talks on the development work on toll transmission systems were given on June 3 to visitors from the Navy Postgraduate School. The program included the following: *Coaxial Systems* by L. G. Abraham; *Coaxial Television Terminals* by L. W. Morrison; *Video and Microwave Television Systems* by J. F. Wentz; *Coaxial Telephone Terminals* by R. E. Crane; *Pulse Transmission Systems* by H. S. Black; and *Transmission Measurements* by H. J. Fisher.

P. H. Betts, E. G. D. Paterson and A. C. Peterson were in Burlington to attend a quality survey conference on mobile radio telephone equipment.

L. A. Dorff, V. A. Douglas, H. W. Evans, D. Mitchell, W. R. Young and S. B. Wright visited New Haven and other Connecticut cities in connection with coördinated transmission tests on The Southern New England Telephone Company's highway mobile radio telephone systems.

F. J. Skinner and A. E. Ruppel made tests at White Plains and the Hawthorne Barracks of the New York State Police Department in connection with a communication network being provided by the New York Company.

L. Y. Lacy and R. H. Ricker discussed general mobile radio telephone equipment problems at Winston-Salem.

A. E. Ruppel discussed the preparation of instruction books covering general mobile radio telephone equipment at the plant of the Radio Corporation of America in Camden.

M. C. Biskeborn visited the Geophysical Instrument Company in Arlington, Va., to discuss special equipment.

R. E. Alberts and C. R. Noble of the Point Breeze group were at Murray Hill discussing lead-covered cable problems.

C. S. Gordon and C. C. Lawson reviewed insulated wire problems at Point Breeze.

J. A. Hall was at the Patent Office in Washington during May in connection with various patent matters.

K. G. Van Wynen has been elected President of the Ramsey, N. J., Board of Education.

K. G. Jansky served as chairman of Session V on Cosmic Noise at the Conference on Radio Propagation in Washington on May 10. A. B. Crawford attended Session VI on the Propagation of VHF Waves.

Mathematics and the "Busy Hour"→

To tell a popular audience about mathematical probability, E. C. Molina, and later his disciple, Roger Wilkinson, use a stage property in the form of a regular hexahedron about six inches each way. Its pattern of dots, from one to six on a side, suggests that it might be used in some game of chance. But the lecturer shows that it is a perfect analogue for the probability element in telephone trunking problems. An even better analogue is the icosahedron which has a one-in-twenty chance of turning up any particular face and which is untainted by gambling.

Regular polyhedrons were studied extensively by the pupils of Plato. There are only five; can you name them?

BORATORIES

RECORD